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Biomolecules Class 11 Notes | CBSE Biology Chapter 9

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Biomolecules Class 11 Notes | CBSE Biology Chapter 9

Biomolecules is Chapter 9 of CBSE Class 11 Biology — the chapter that finally tells you what living things are actually *made of*. From the protein in an egg to the DNA in your cells and the sugar in your blood, every living structure is built from a handful of carbon-based molecules. Once you can classify these molecules and explain what each one does, half of Biochemistry, Cell Biology, and even Human Physiology falls into place.

By the end of these notes you will be able to analyse the chemical composition of living tissue, tell primary from secondary metabolites, classify carbohydrates, proteins, lipids and nucleic acids, describe the four levels of protein structure, and explain exactly how enzymes work and what speeds them up or slows them down. This is a high-yield chapter for NEET (enzymes and protein structure are repeat favourites) and carries solid weight in your board exam too.

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Key Concepts

1. Analysis of Chemical Composition

To find what a tissue is made of, you grind it with acid (trichloroacetic acid), filter it, and you get two fractions. The **acid-soluble pool** contains small molecules; the **acid-insoluble fraction** contains the big ones.

Small molecules (molecular weight 18–800 daltons) — amino acids, sugars, nucleotides, lipids — make up the **acid-soluble pool**. Macromolecules — proteins, nucleic acids, polysaccharides — form the **acid-insoluble fraction**. Lipids are an exception: they are technically not very large but get into the insoluble fraction because they form membranes that break into vesicles.

Key idea: Water is the most abundant chemical in any cell (about 70–90%). Among the macromolecules, proteins are the most abundant by amount.

Most Abundant in Living Things

- **Most abundant chemical overall:** water
 - **Most abundant biomacromolecule:** protein (in the whole biosphere, cellulose, a carbohydrate, is the most abundant organic compound)
 - **Most abundant organic compound in nature:** cellulose
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2. Primary and Secondary Metabolites

The thousands of small carbon compounds in a cell are called **metabolites**. They come in two groups based on whether they are part of basic life processes.

Primary metabolites have clearly identifiable roles in normal physiology — amino acids, sugars, nucleotides, lipids. They are found in all organisms and are directly involved in growth, development and reproduction.

Secondary metabolites are products like alkaloids, flavonoids, rubber, essential oils, antibiotics, pigments, and toxins. Their role in the host's own physiology is often not obvious, but many are useful to humans (medicines, dyes, drugs).

Secondary Metabolite	Example
Pigments	Carotenoids, anthocyanins
Alkaloids	Morphine, codeine
Drugs	Vinblastin, curcumin
Toxins	Abrin, ricin
Polymeric substances	Rubber, gums, cellulose

3. Carbohydrates

Carbohydrates are polyhydroxy aldehydes or ketones, or compounds that yield these on hydrolysis. In simple words, they are the cell's **sugars and their polymers**. General formula: $(CH_2O)_n$.

Three Classes of Carbohydrates

- **Monosaccharides:** single sugar units, cannot be hydrolysed further — glucose, fructose, ribose, galactose.
- **Oligosaccharides:** 2–10 units — sucrose (glucose + fructose), maltose (glucose + glucose), lactose (glucose + galactose).
- **Polysaccharides:** long chains of many units — starch, glycogen, cellulose, inulin, chitin.

Storage vs structural: Starch (plants) and glycogen (animals) are storage polysaccharides; cellulose (plant cell wall) and chitin (fungal wall and insect exoskeleton) are structural. Starch forms a helix and holds I_2 to give blue colour; cellulose does not, because of straight, H-bonded chains.

The bond that links two monosaccharides is a **glycosidic bond**, formed by loss of a water molecule (a condensation reaction).

4. Proteins and Amino Acids

Proteins are the most diverse and abundant biomacromolecules — they are polymers of **amino acids** joined by peptide bonds. There are **20 standard amino acids** used to build all proteins.

Structure of an Amino Acid

Each amino acid has a central carbon (the α -carbon) bonded to four groups: an **amino group ($-\text{NH}_2$)**, a **carboxyl group ($-\text{COOH}$)**, a **hydrogen**, and a variable **R-group (side chain)**. The R-group decides whether the amino acid is acidic, basic, neutral or aromatic.

- **Acidic:** glutamic acid (two $-\text{COOH}$)
- **Basic:** lysine (two $-\text{NH}_2$)
- **Neutral:** valine (one $-\text{COOH}$, one $-\text{NH}_2$)
- **Aromatic:** tyrosine, phenylalanine, tryptophan

Amino acids are **zwitterions** — at a particular pH they carry both a positive and a negative charge at once. The amino acids linked into proteins are all of the L-form.

The Peptide Bond

The $-\text{COOH}$ of one amino acid joins the $-\text{NH}_2$ of the next, releasing water. This **peptide bond ($-\text{CO}-\text{NH}-$)** is what links amino acids into a chain (a polypeptide).

5. Structure of Proteins — Four Levels

A protein is not just a chain — it folds into a precise 3-D shape, and that shape is its function. Biologists describe this folding in four levels.

Level	What it is	Example / Bond
Primary	The linear sequence of amino acids, with a defined N-terminal and C-terminal end	Peptide bonds
Secondary	Local coiling/folding of the chain into regular shapes	α -helix and β -pleated sheet, held by H-bonds
Tertiary	Overall 3-D folding of the whole chain into a functional shape	H-bonds, disulphide, ionic, hydrophobic
Quaternary	Two or more polypeptide subunits assembled together	Haemoglobin (4 subunits: $2\alpha + 2\beta$)

[DIAGRAM: A polypeptide ribbon showing an α -helix region and a flat β -pleated sheet region, then folded into a compact tertiary globule, with four such globules clustered as a quaternary structure.]

Note: Collagen is the most abundant protein in the animal world; RuBisCO (in chloroplasts) is the most abundant protein in the whole biosphere.

6. Lipids

Lipids are water-insoluble (hydrophobic) biomolecules — the fats, oils, waxes and phospholipids of the cell. They are not true macromolecules (their molecular weight is not very high), but they end up in the acid-insoluble fraction.

- **Fatty acids:** a carboxyl group attached to an R-group (carbon chain). Saturated (no double bond, e.g. palmitic acid) or unsaturated (one or more double bonds, e.g. oleic acid).
- **Glycerides:** fatty acids esterified to glycerol — monoglycerides, diglycerides, triglycerides (the main storage fat).
- **Phospholipids:** contain phosphorus and a phosphorylated group; the main building block of cell membranes (e.g. lecithin).

Fats vs oils: fats are solid at room temperature (more saturated); oils have a low melting point and stay liquid (more unsaturated).

7. Nucleic Acids

Nucleic acids — **DNA and RNA** — are the information-carrying macromolecules of the cell. They are long polymers of **nucleotides**.

Building Block: the Nucleotide

Each nucleotide has three parts: a **nitrogenous base**, a **pentose sugar**, and a **phosphate group**.

- **Bases — purines:** adenine (A) and guanine (G), with two rings.
- **Bases — pyrimidines:** cytosine (C), thymine (T, in DNA), uracil (U, in RNA), with one ring.
- **Sugar:** deoxyribose in DNA, ribose in RNA.

A base + sugar = **nucleoside**; a nucleoside + phosphate = **nucleotide**. Nucleotides are joined by **phosphodiester bonds** to form a chain.

The DNA Double Helix (Watson–Crick)

- Two antiparallel strands wound into a right-handed helix.
- Base pairing by H-bonds: **A=T** (2 H-bonds), **G≡C** (3 H-bonds) — this is complementarity.
- Diameter 2 nm; one full turn = 3.4 nm and contains 10 base pairs; distance between two bases = 0.34 nm.

Chargaff's rule: in any double-stranded DNA, A = T and G = C, so purines = pyrimidines.

8. Enzymes — Nature and Classification

Almost all enzymes are **proteins** that act as **biocatalysts** — they speed up reactions in the cell without being used up. (A few RNA molecules also act as catalysts; these are called **ribozymes**.)

Enzymes have an **active site**, a pocket whose shape fits the substrate. They dramatically lower the **activation energy** of a reaction, so it proceeds much faster — typically millions of times faster than the uncatalysed rate.

Six Classes of Enzymes (IUBMB)

Class	Reaction Catalysed
Oxidoreductases	Oxidation–reduction (transfer of H/electrons)
Transferases	Transfer of a group between molecules
Hydrolases	Hydrolysis (breaking bonds using water)
Lyases	Removal of groups to form double bonds (not by hydrolysis)
Isomerases	Rearrangement within a molecule (isomer formation)
Ligases	Joining of two molecules using ATP

9. Mechanism of Enzyme Action

The substrate (S) binds the enzyme's active site to form an **enzyme-substrate complex (ES)**, the bonds are strained and broken/formed, the product (P) is released, and the enzyme is freed to work again.



- The active site fits the substrate like a **lock and key** (and adjusts slightly — the induced-fit idea).
- Enzymes provide an alternative path with **lower activation energy**, so the transition state is reached more easily.
- Each enzyme is highly **specific** for its substrate.

[DIAGRAM: Energy curve showing a high activation-energy hump for the uncatalysed reaction and a much lower hump for the enzyme-catalysed reaction, with substrate and product levels marked.]

10. Factors Affecting Enzyme Activity

An enzyme works best under specific conditions; push it outside its comfort zone and its activity drops, often because the protein **denatures** (loses its shape).

- **Temperature:** activity rises with temperature up to an **optimum**, then falls sharply as the enzyme denatures. Most human enzymes peak near 37 °C.
- **pH:** each enzyme has an optimum pH (pepsin works in acidic ~2, trypsin in alkaline ~8). Extreme pH denatures it.

- **Substrate concentration:** rate rises with substrate, then levels off (saturation) once all active sites are occupied — giving the maximum velocity V_{max} .
- **Inhibitors:** a **competitive inhibitor** resembles the substrate and competes for the active site (e.g. malonate competes with succinate on succinic dehydrogenase).

[DIAGRAM: A bell-shaped curve of enzyme activity vs temperature peaking at the optimum, and a similar bell curve for activity vs pH.]

11. Cofactors

Many enzymes need an extra non-protein helper to become active. The protein part on its own is the **apoenzyme**; the complete active enzyme (apoenzyme + cofactor) is the **holoenzyme**.

Cofactor Type	Description	Example
Prosthetic group	Organic, tightly (covalently) bound to the apoenzyme	Haem in peroxidase / catalase
Coenzyme	Organic, loosely bound; often a vitamin derivative	NAD, FAD (from niacin, riboflavin)
Metal ion (activator)	Inorganic ion forming a coordinate bond with the enzyme	Zn^{2+} in carboxypeptidase, Mg^{2+}

Key idea: remove the cofactor and the apoenzyme cannot catalyse the reaction — the cofactor completes the active enzyme.

Weightage in Board & Entrance Exams

Exam	Typical Weightage	Most-Tested Areas
CBSE Board (Class 11)	4–6 marks (Unit: Cell — Structure and Function)	Protein structure, enzyme action, classification of biomolecules
NEET	2–3 questions	Enzymes (classes, cofactors, factors), protein structure levels, DNA/RNA bases
School / competitive	High-frequency	Primary vs secondary metabolites, polysaccharides, lock-and-key

[TABLE: Question-type split — VSA (1 mark): definitions, bonds, examples; SA (2–3 marks): classification, four levels of protein structure, factors affecting enzymes; LA (5 marks): enzyme mechanism with activation-energy diagram, complete classification of carbohydrates/proteins.]

Important Definitions

Term	Definition
Metabolite	A small carbon compound found in living tissue; primary (in basic life) or secondary (special products)
Macromolecule	A large biomolecule (MW > ~1000 Da) in the acid-insoluble fraction — protein, nucleic acid, polysaccharide
Glycosidic bond	Bond linking two monosaccharides, formed by loss of water
Peptide bond	–CO–NH– bond linking the –COOH of one amino acid to the –NH ₂ of the next
Zwitterion	A molecule (e.g. an amino acid) bearing both positive and negative charge at the same time
Nucleotide	Nitrogenous base + pentose sugar + phosphate; the monomer of nucleic acids
Enzyme	A protein biocatalyst that lowers a reaction's activation energy without being consumed
Active site	The pocket on an enzyme where the substrate binds and reacts
Activation energy	The energy barrier that must be crossed for a reaction to proceed
Holoenzyme	A complete, active enzyme = apoenzyme + cofactor

Solved & Illustrative Examples

Example 1

A tissue is ground in trichloroacetic acid and filtered. In which fraction will you find (a) glucose and (b) cellulose?

Answer: (a) Glucose is a small molecule, so it is in the **acid-soluble pool**. (b) Cellulose is a polysaccharide (macromolecule), so it is in the **acid-insoluble fraction**.

Example 2

Classify the following as primary or secondary metabolites: amino acids, morphine, nucleotides, rubber.

Answer: Amino acids and nucleotides are **primary** metabolites; morphine and rubber are **secondary** metabolites.

Example 3

A strand of DNA has 30% adenine. Using Chargaff's rule, find the percentage of guanine.

Answer: $A = T = 30\%$, so $A + T = 60\%$. Remaining 40% is $G + C$, and $G = C$, so guanine = **20%**.

Example 4

Name the bond linking (a) two monosaccharides, (b) two amino acids, (c) two nucleotides.

Answer: (a) glycosidic bond, (b) peptide bond, (c) phosphodiester bond.

Example 5

Haemoglobin is made of four polypeptide chains assembled together. Which level of protein structure does this represent?

Answer: Quaternary structure (two α and two β subunits).

Example 6

Malonate inhibits succinic dehydrogenase by resembling its substrate succinate. What kind of inhibition is this, and how can it be overcome?

Answer: It is **competitive inhibition** — malonate competes with succinate for the active site. It can be overcome by **increasing the substrate (succinate) concentration**.

Important Questions for Board Exams

1-Mark Questions (VSA)

1. Name the most abundant chemical in a living cell.
2. What is a glycosidic bond?
3. Give one example each of a purine and a pyrimidine.
4. Differentiate between a nucleoside and a nucleotide in one line.
5. What is the difference between apoenzyme and holoenzyme?

2–3-Mark Questions (SA)

1. Distinguish between primary and secondary metabolites with two examples each.
2. Draw the general structure of an amino acid and label its four groups.
3. List the four levels of protein structure and name the bonds stabilising each.
4. Explain how temperature and pH affect enzyme activity.
5. State and explain Chargaff's rule with the base-pairing it implies.

5-Mark Questions (LA)

1. Describe the mechanism of enzyme action and explain, with an energy diagram, how an enzyme lowers activation energy.
 2. Classify carbohydrates with examples, and distinguish storage from structural polysaccharides.
 3. Classify enzymes into their six IUBMB classes with the type of reaction each catalyses, and explain the role of cofactors.
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Quick Revision Points

- Water is the most abundant cell chemical; protein the most abundant macromolecule; cellulose the most abundant organic compound in nature
 - Acid-soluble pool = small molecules; acid-insoluble fraction = proteins, nucleic acids, polysaccharides (and lipids)
 - Primary metabolites (amino acids, sugars, nucleotides, lipids) vs secondary metabolites (alkaloids, pigments, rubber, toxins)
 - Carbohydrates: mono- / oligo- / polysaccharides; linked by glycosidic bonds; starch + glycogen store, cellulose + chitin structure
 - 20 amino acids → joined by peptide bonds; amino acids are zwitterions, all L-form
 - Protein structure: primary (sequence), secondary (α -helix, β -sheet), tertiary (3-D fold), quaternary (subunits)
 - Lipids: fatty acids, glycerides, phospholipids; fats solid (saturated), oils liquid (unsaturated)
 - Nucleotide = base + pentose sugar + phosphate; purines A, G; pyrimidines C, T, U; A=T (2 H-bonds), G $\equiv$ C (3 H-bonds)
 - Enzymes are protein biocatalysts; lower activation energy; six classes (oxidoreductase, transferase, hydrolase, lyase, isomerase, ligase)
 - Mechanism: $E + S \rightarrow ES \rightarrow EP \rightarrow E + P$; lock-and-key / induced fit; highly specific
 - Activity affected by temperature, pH, substrate concentration, inhibitors (competitive)
 - Cofactors: prosthetic group, coenzyme, metal-ion activator; apoenzyme + cofactor = holoenzyme
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Next Chapter: Chapter 16 — Digestion and Absorption



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