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Biology Class 9 — Punjab Board (PECTAA)

CHAPTER 6

Biomolecules

Key Concepts · Definitions · Short & Long Questions · MCQs · Diagrams · Exam Tips

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Chapter 6: Biomolecules

Chapter 6 introduces the large molecules that living things make and depend on. Biochemistry studies the chemical processes inside organisms, while molecular biology studies the structure and work of their molecules. The four main groups of biomolecules are carbohydrates, proteins, lipids and nucleic acids.

These notes cover each group in turn: what it is made of, its main types, where it comes from in the diet and what it does in the body. The chapter ends with how DNA stores hereditary information and how that information is copied into RNA and used to build proteins.

Learning Objectives

- Define biochemistry, molecular biology, biomolecules and metabolism.
- Classify carbohydrates into monosaccharides, disaccharides and polysaccharides with examples.
- Describe the structure of an amino acid and the functions of proteins.
- Describe fatty acids, fats, oils and phospholipids and the functions of lipids.
- Describe the structure of DNA and RNA and the roles of the three types of RNA.
- Explain transcription and translation (the central dogma).

Key Concepts

6.1 Biomolecules and Metabolism

Biomolecules are the molecules made by living organisms. Most are very large and are called macromolecules. Carbohydrates mainly supply and store energy; proteins build structures and act as enzymes and hormones; lipids store energy, insulate and build membranes; DNA stores genetic information and RNA helps use that information to make proteins.

Biomolecules make up about 93 percent of the dry mass of protoplasm. Proteins form the largest share (about half), followed by nucleic acids, carbohydrates and lipids. The remaining dry mass is vitamins and inorganic substances such as salts.

All the chemical reactions of an organism together are called metabolism. Anabolism builds complex molecules from simple ones and uses energy; catabolism breaks complex molecules into simpler ones and releases energy.

6.2 Carbohydrates

Carbohydrates are compounds of carbon, hydrogen and oxygen in which hydrogen and oxygen are in the ratio 2:1, as in water. Their general formula is Cn(H2O)n, and they are also called saccharides (sugars).

Monosaccharides are single sugar units with 3 to 7 carbon atoms. They dissolve easily and taste sweet. Pentoses (5 carbons) include ribose and deoxyribose; hexoses (6 carbons, C6H12O6) include glucose, fructose and galactose.

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Disaccharides are made of two monosaccharides. They are less soluble and less sweet. Sucrose (table sugar) is glucose + fructose, maltose is glucose + glucose, and lactose (milk sugar) is found in dairy products.

Polysaccharides contain hundreds to thousands of sugar units. They are insoluble and tasteless. Starch stores food in plants; glycogen, the highly branched 'animal starch', is stored in liver and muscles; cellulose forms plant cell walls and is the most abundant carbohydrate; chitin is found in the exoskeletons of insects and crabs and in fungal cell walls.

Carbohydrates are the main source of energy: glucose is broken down in cellular respiration. Indigestible cellulose acts as dietary fibre and helps bowel movement, ribose and deoxyribose are parts of RNA and DNA, and plants move sugar around their bodies as sucrose.

6.3 Proteins

Proteins are polymers of amino acids and are the most abundant biomolecules in a cell. The number and order of amino acids differ from protein to protein; for example insulin has 51 amino acids, while haemoglobin has several hundred.

An amino acid has a central carbon atom attached to four groups: an amino group (NH2), a carboxyl group (COOH), a hydrogen atom and a side group called R. The R group is different in each amino acid: it is H in glycine and CH3 in alanine. About 20 kinds of amino acids build most proteins. Nine are essential (must come from food) and eleven are non-essential (the body can make them).

Good sources are meat, fish, eggs, milk, pulses and beans. Proteins build membranes and structures such as hair and nails (keratin) and cartilage (collagen); act as enzymes and some hormones; carry oxygen (haemoglobin); cause muscle contraction (actin and myosin); clot blood (fibrin); and defend the body (antibodies).

6.4 Lipids

Lipids are organic compounds that do not dissolve in water but dissolve in organic solvents such as alcohol and ether. Most are made of glycerol (a three-carbon alcohol with three -OH groups) and fatty acids (long hydrocarbon chains ending in a carboxyl group).

Saturated fatty acids have only single bonds between carbon atoms and are solid at room temperature. Unsaturated fatty acids have one or more double bonds and are liquid at room temperature.

Fats and oils contain one glycerol and three fatty acids. Fats (mostly animal) contain saturated fatty acids and are solid; oils (mostly plant, such as olive and corn oil) contain unsaturated fatty acids and are liquid. Phospholipids have one glycerol, two fatty acids and a phosphate group, and form the basic structure of all membranes.

Lipids are the richest store of energy and are kept in adipose tissue as a long-term reserve. They also build membranes, insulate the body and cushion organs, form steroid hormones from cholesterol, and help absorb fat-soluble vitamins A, D, E and K.

6.5 Nucleic Acids: DNA and RNA

Nucleic acids are made of nucleotides. Each nucleotide has a pentose sugar, a nitrogenous base and a phosphate group.

DNA nucleotides contain deoxyribose and one of four bases: adenine (A), thymine (T), cytosine (C) and guanine (G). In 1953 James Watson and Francis Crick proposed the double helix model: two strands of nucleotides coil around each other, held by hydrogen bonds between bases. Pairing is specific: A pairs with T (two hydrogen bonds) and C pairs with G (three hydrogen bonds).

The sequence of bases in DNA is the hereditary information. A segment of DNA that codes for one protein (polypeptide) is a gene. DNA is passed from parents to offspring, carrying this information to the next generation.

RNA is single-stranded. Its nucleotides contain ribose, and the base uracil (U) replaces thymine. Messenger RNA (mRNA) carries the copied gene to the ribosome; transfer RNA (tRNA) brings the correct amino acids; ribosomal RNA (rRNA) forms part of the ribosome itself.

6.6 How DNA and RNA Work

Transcription: the base sequence of a gene is copied into a molecule of mRNA in the nucleus. Translation: the mRNA travels to a ribosome, which reads its sequence and joins amino acids, delivered by tRNA, in the matching order to build a protein.

This one-way flow of information, DNA → RNA → protein, is called the central dogma of molecular biology.

Important Definitions

Biochemistry
The study of the chemical substances and processes in living organisms.

Molecular biology
The study of the structure and functions of biomolecules.

Biomolecules
Molecules produced by living organisms, such as carbohydrates, proteins, lipids and nucleic acids.

Metabolism
All the chemical reactions taking place in an organism.

Anabolism
Metabolism that builds complex molecules from simpler ones, using energy.

Catabolism
Metabolism that breaks complex molecules into simpler ones, releasing energy.

Monosaccharide
A single sugar unit, such as glucose or ribose.

Disaccharide
A sugar made of two monosaccharide units, such as sucrose.

Polysaccharide
A large carbohydrate made of many sugar units, such as starch or cellulose.

Glycogen
A highly branched storage polysaccharide of glucose found in animal liver and muscles.

Amino acid
The building unit of proteins, with an amino group, a carboxyl group, a hydrogen atom and an R group on a central carbon.

Essential amino acids
Amino acids the body cannot make, which must be obtained from food.

Saturated fatty acid
A fatty acid with only single bonds between its carbon atoms.

Unsaturated fatty acid
A fatty acid with one or more carbon-carbon double bonds.

Phospholipid
A lipid of glycerol, two fatty acids and a phosphate group that forms membranes.

Nucleotide
The unit of nucleic acids, made of a pentose sugar, a nitrogenous base and a phosphate.

Gene
A segment of DNA whose base sequence codes for a particular protein.

Transcription
Copying of a gene's DNA sequence into messenger RNA.

Translation
Building of a protein at the ribosome according to the sequence of mRNA.

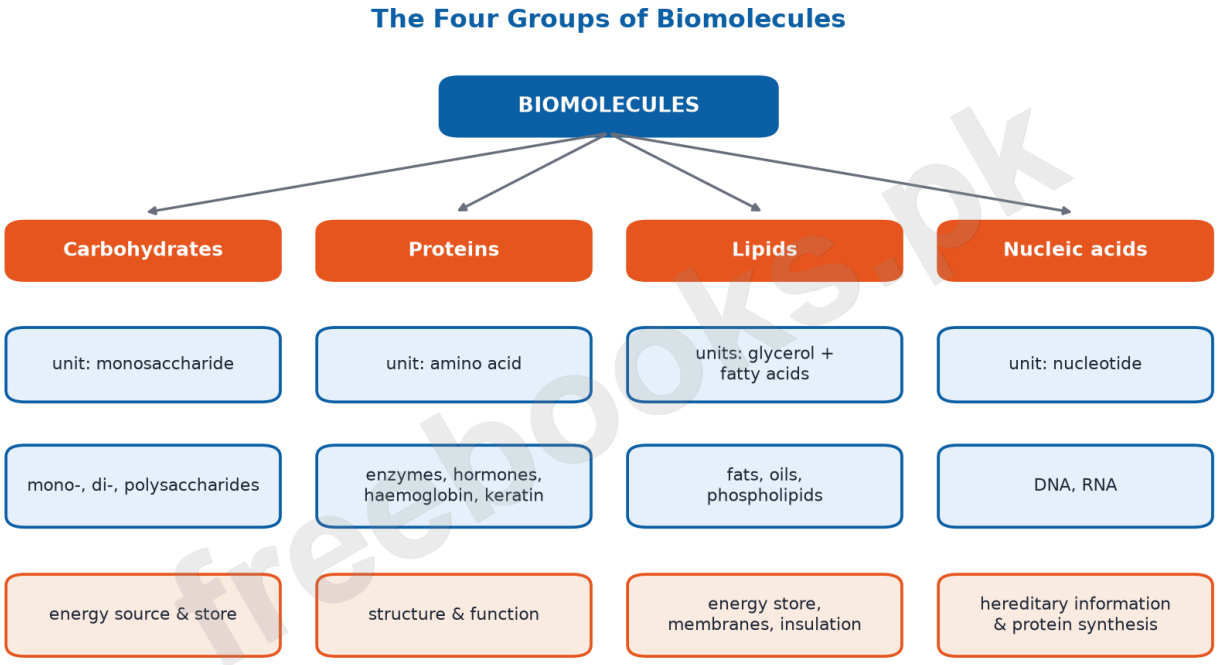
Key Facts at a Glance

Topic	Key point
Biomolecules in dry protoplasm	About 93%
Largest share of dry mass	Proteins, about 50%

Carbohydrate formula	Cn(H2O)n; H:O = 2:1
Sucrose	Glucose + fructose
Maltose	Glucose + glucose
Most abundant carbohydrate	Cellulose
Amino acids in most proteins	20 (9 essential, 11 non-essential)
Insulin	51 amino acids
Fat / oil	1 glycerol + 3 fatty acids
Phospholipid	1 glycerol + 2 fatty acids + phosphate
DNA model	Double helix, Watson and Crick, 1953
Base pairs	A=T (2 H-bonds), C≡G (3 H-bonds)
RNA differs from DNA	Ribose sugar, uracil instead of thymine, single strand
Central dogma	DNA → (transcription) → mRNA → (translation) → protein

Diagrams

The four groups of biomolecules: A classification chart showing carbohydrates, proteins, lipids and nucleic acids with their units, types and main roles.



Building units: The general structure of an amino acid and of a nucleotide, with each part

labelled.

Building Units: Amino Acid and Nucleotide

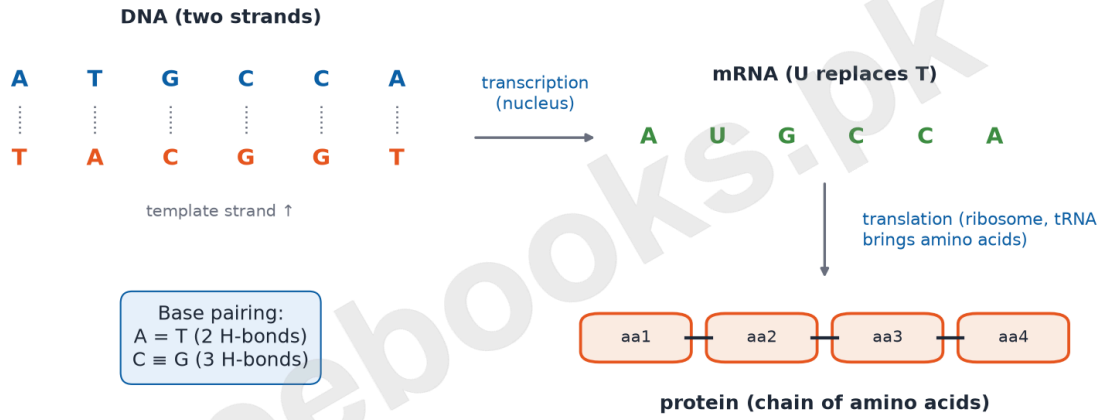


General amino acid
Amino group + carboxyl group + H + R group

Nucleotide
Phosphate + pentose sugar + nitrogenous base
DNA: deoxyribose; A, T, C, G | RNA: ribose; A, U, C, G

DNA, RNA and protein: Base pairing in a DNA segment, transcription into mRNA and translation into a chain of amino acids.

From DNA to Protein (Central Dogma)



Short Questions and Answers

Why are carbohydrates called 'hydrated carbons'?
Because hydrogen and oxygen are present in them in the same 2:1 ratio as in water, so they look like carbon combined with water: Cn(H2O)n.

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How does the taste and solubility change from monosaccharides to polysaccharides?
Monosaccharides are sweet and dissolve easily, disaccharides are less sweet and less soluble, and polysaccharides are tasteless and insoluble.

Why is cellulose useful in our diet even though we cannot digest it?
It acts as dietary fibre, adding bulk to food and helping regular bowel movement.

Compare starch and glycogen.
Both store glucose. Starch is the storage form in plants and has straight and branched chains; glycogen is stored in animal liver and muscles and is much more highly branched.

What makes one amino acid different from another?
Only the side group (R group) differs; the amino group, carboxyl group and hydrogen atom are the same in all.

Why must essential amino acids be included in our diet?
Our body cannot make these nine amino acids, so without them in food it cannot build all the proteins it needs.

Name four proteins and state the job of each.
Haemoglobin carries oxygen, actin and myosin cause muscle contraction, fibrin helps blood to clot, and antibodies defend against pathogens.

Why is butter solid while olive oil is liquid at room temperature?
Butter is rich in saturated fatty acids with only single bonds, while olive oil is rich in unsaturated fatty acids whose double bonds keep it liquid.

Why are lipids a better long-term energy store than carbohydrates?
Lipids are the most energy-rich biomolecules, so a given mass of fat stores more energy; it is held in adipose tissue until needed.

If one strand of DNA reads A-T-G-C, what is the opposite strand?
T-A-C-G, because A always pairs with T and G always pairs with C.

Give three differences between DNA and RNA.
DNA is double-stranded, has deoxyribose and contains thymine; RNA is single-stranded, has ribose and contains uracil instead of thymine.

What is a gene?
A segment of DNA whose sequence of nucleotides carries the information to make one particular protein.

What is the role of tRNA in protein synthesis?
It brings specific amino acids to the ribosome so they are added in the order set by the mRNA.

Long Questions and Answers

Describe the three classes of carbohydrates.

What are monosaccharides?

Single sugar units with 3 to 7 carbons that are sweet and soluble. Examples are the pentoses ribose and deoxyribose and the hexoses glucose, fructose and galactose.

What are disaccharides?

Sugars made of two monosaccharides, less sweet and less soluble. Sucrose is glucose + fructose (from sugar cane and beet), maltose is two glucose units (in cereals), and lactose is found in milk.

What are polysaccharides?

Large, insoluble, tasteless chains of many sugar units: starch (plant store), glycogen (animal store), cellulose (plant cell walls) and chitin (insect exoskeletons, fungal walls).

What are the main roles of carbohydrates?

They are the main fuel for respiration, they store energy, cellulose gives plants support and provides dietary fibre, and pentose sugars form part of DNA and RNA.

Describe the structure and functions of proteins.

What are proteins made of?

Proteins are long chains of amino acids joined in a specific number and order. About 20 kinds of amino acids make most proteins.

What is the structure of an amino acid?

A central carbon carries an amino group (NH_2), a carboxyl group ($COOH$), a hydrogen atom and an R group. The R group differs: H in glycine, CH_3 in alanine.

What structural roles do proteins have?

They form part of every cell membrane, and proteins such as keratin and collagen make up hair, nails and cartilage.

What other functions do proteins perform?

They act as enzymes and some hormones, haemoglobin carries oxygen, actin and myosin contract muscles, fibrin clots blood and antibodies fight pathogens.

Describe lipids, their types and functions.

What are lipids made of?

Most lipids are made of glycerol, a three-carbon alcohol, joined to fatty acids, which are long hydrocarbon chains with a carboxyl group.

How do saturated and unsaturated fatty acids differ?

Saturated fatty acids have only single carbon-carbon bonds and are solid at room temperature;

unsaturated fatty acids have one or more double bonds and are liquid.

What are fats, oils and phospholipids?

Fats and oils have one glycerol and three fatty acids; fats are solid (saturated), oils are liquid (unsaturated). Phospholipids have one glycerol, two fatty acids and a phosphate and form membranes.

What are the functions of lipids?

They store energy long-term in adipose tissue, build membranes, insulate and cushion organs, form steroid hormones and help absorb vitamins A, D, E and K.

Explain the structure of DNA and how its information is used to make proteins.

What is a nucleotide?

The unit of nucleic acids, made of a pentose sugar, a nitrogenous base and a phosphate group.

What is the double helix model?

Proposed by Watson and Crick in 1953, it shows DNA as two nucleotide strands coiled around each other and joined by hydrogen bonds between their bases.

How are bases paired?

Adenine always pairs with thymine through two hydrogen bonds, and cytosine always pairs with guanine through three hydrogen bonds.

How is a protein made from a gene?

In transcription the gene's sequence is copied into mRNA. In translation the ribosome reads the mRNA and tRNA brings amino acids, which are joined in the matching order to form a protein.

Multiple Choice Questions (MCQs)

Which of these is a pentose sugar? (A) Glucose (B) Fructose (C) Ribose (D) Galactose
Correct answer: (C) Ribose. Ribose has five carbons.

Table sugar (sucrose) is made of: (A) Glucose + glucose (B) Glucose + fructose (C) Glucose + galactose (D) Fructose + fructose
Correct answer: (B) Glucose + fructose. Sucrose = glucose + fructose.

Glycogen is stored mainly in: (A) Liver and muscles (B) Bones (C) Skin (D) Plant seeds
Correct answer: (A) Liver and muscles. Glycogen is animal starch.

The cell wall of fungi is made of: (A) Cellulose (B) Starch (C) Chitin (D) Glycogen
Correct answer: (C) Chitin. Fungal walls contain chitin.

In alanine, the R group is: (A) H (B) CH3 (C) OH (D) COOH
Correct answer: (B) CH3. Glycine has H; alanine has CH3.

How many essential amino acids must come from food? (A) 5 (B) 9 (C) 11 (D) 20
Correct answer: (B) 9. Nine are essential.

The protein that helps blood to clot is: (A) Keratin (B) Fibrin (C) Myosin (D) Insulin
Correct answer: (B) Fibrin. Fibrin forms the clot.

A fatty acid with double bonds between carbons is: (A) Saturated (B) Unsaturated (C) A phospholipid (D) Glycerol
Correct answer: (B) Unsaturated. Double bonds = unsaturated.

A phospholipid contains: (A) 3 fatty acids (B) 2 fatty acids and a phosphate (C) Amino acids (D) Ribose
Correct answer: (B) 2 fatty acids and a phosphate. Glycerol + 2 fatty acids + phosphate.

Steroid hormones are made from: (A) Glucose (B) Cholesterol (C) Cellulose (D) RNA
Correct answer: (B) Cholesterol. Cholesterol is the starting lipid.

Cytosine pairs with: (A) Adenine (B) Thymine (C) Guanine (D) Uracil
Correct answer: (C) Guanine. C pairs with G by three hydrogen bonds.

Which base occurs in RNA but not in DNA? (A) Adenine (B) Uracil (C) Thymine (D) Guanine
Correct answer: (B) Uracil. Uracil replaces thymine in RNA.

Copying a gene into mRNA is called: (A) Translation (B) Replication (C) Transcription (D) Mutation
Correct answer: (C) Transcription. DNA → mRNA is transcription.

The RNA that brings amino acids to the ribosome is: (A) mRNA (B) tRNA (C) rRNA (D) DNA
Correct answer: (B) tRNA. Transfer RNA carries amino acids.

Breaking glucose to release energy is an example of: (A) Anabolism (B) Catabolism (C) Transcription (D) Photosynthesis
Correct answer: (B) Catabolism. Breakdown releasing energy is catabolism.

Quick Revision Summary

- Biomolecules: carbohydrates, proteins, lipids, nucleic acids (≈93% of dry protoplasm; proteins ≈50%).
- Metabolism = anabolism (build, uses energy) + catabolism (break, releases energy).
- Carbohydrates Cn(H2O)n: mono- (glucose, ribose), di- (sucrose, maltose, lactose), poly- (starch, glycogen, cellulose, chitin).
- Protein = chain of amino acids; amino acid = NH2 + COOH + H + R on a central carbon; 20

types, 9 essential.
- Lipids = glycerol + fatty acids; saturated (solid, single bonds) vs unsaturated (liquid, double bonds); phospholipids build membranes.
- Nucleotide = sugar + base + phosphate. DNA: double helix, deoxyribose, A-T and C-G. RNA: single strand, ribose, U instead of T; mRNA, tRNA, rRNA.
- Gene → transcription → mRNA → translation at ribosome → protein.

Exam Tips

- Make a three-column table (type, example, source/function) for carbohydrates; it answers most short questions.
- Practise drawing the general amino acid structure and the glycerol + fatty acid structure; they are common drawing questions.
- Remember the base-pair rule with 'AT 2, CG 3' (number of hydrogen bonds).
- Do not mix up transcription (DNA → mRNA, in nucleus) and translation (mRNA → protein, at ribosome).
- For 'DNA vs RNA', give at least three differences: strands, sugar, base (T vs U).

Note on Facts

The textbook names only James Watson and Francis Crick for the double helix. The 1962 Nobel Prize was shared with Maurice Wilkins, and the X-ray images made by Rosalind Franklin were key evidence for the model.

The textbook says enzymes catalyse all biochemical reactions and that all enzymes are proteins. Chapter 7 of the same book notes that some RNA molecules (ribozymes) also act as catalysts.

The textbook calls chitin a modified form of cellulose. It is better described as a cellulose-like polysaccharide: its sugar units carry nitrogen-containing groups that cellulose does not have.