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CUET · BIOLOGY · CLASS XI · CODE 304

Cell - The Unit of Life

CUET unit: Cell Structure and Function → Cell - The Unit of Life

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📌 Snapshot

- Establishes the **cell** as the fundamental structural and functional unit of all living organisms, codified by the cell theory of Schleiden, Schwann and Virchow.
- Contrasts **prokaryotic** (no membrane-bound nucleus, 70S ribosomes, mesosomes, naked DNA + plasmids) and **eukaryotic** organisation (compartmentalised cytoplasm with membrane-bound organelles, 80S cytoplasmic ribosomes, chromosomes).
- Walks the eukaryotic toolkit organelle-by-organelle: fluid-mosaic plasma membrane, cell wall, endomembrane system (ER, Golgi, lysosomes, vacuoles), mitochondria, plastids, ribosomes, cytoskeleton, cilia/flagella with 9+2 axoneme, centrosome, nucleus and microbodies.
- A high-yield CUET unit — definitions, "S" values, double-membrane lists, cristae vs. cisternae vs. thylakoids confusions, and chromosome morphology are NTA favourites.

📖 Detailed Notes

2.1 Core concepts

- Cell is the fundamental structural and functional unit of all living organisms; anything less than a complete cell cannot ensure independent living (NCERT §8.1, p. 87). Antonie Von Leeuwenhoek first saw and described a live cell; Robert Brown later discovered the nucleus (NCERT §8.1, p. 87).
- **Cell theory:** Matthias Schleiden (1838, German botanist) — all plants are composed of cells forming tissues; Theodore Schwann (1839, German zoologist) — animal cells have a thin outer "plasma membrane" and cell wall is unique to plants; Rudolf Virchow (1855) added that all cells arise from pre-existing cells (Omnis cellula-e cellula). Modern theory: (i) all living organisms are composed of cells and products of cells, (ii) all cells arise from pre-existing cells (NCERT §8.2, p. 87–88).
- **Eukaryotic vs prokaryotic:** eukaryotic cells have membrane-bound nuclei and organelles; prokaryotic cells lack membrane-bound nucleus and organelles (except ribosomes). Cytoplasm is the main arena of cellular activity in both (NCERT §8.3, p. 88).

- **Size & shape range:** Mycoplasmas (smallest cells) are 0.3 µm; bacteria 3–5 µm; human RBCs ~7.0 µm; ostrich egg is the largest isolated single cell; nerve cells are among the longest. Cells may be disc-like, polygonal, columnar, cuboidal, thread-like or irregular (NCERT §8.3, p. 88–89, Figure 8.1).
- **Prokaryotes** include bacteria, blue-green algae, mycoplasma and PPLO (Pleuro Pneumonia Like Organisms). Four bacterial shapes: bacillus (rod), coccus (spherical), vibrio (comma), spirillum (spiral) (NCERT §8.4, p. 89). Genetic material is naked circular DNA; many bacteria also carry **plasmids** (small extra circular DNA) which confer phenotypic traits like antibiotic resistance (NCERT §8.4, p. 90).
- **Cell envelope (Gram +/−):** outermost glycocalyx → cell wall → plasma membrane, acting as a single protective unit; bacteria taking Gram stain are **Gram positive**, others **Gram negative**. Glycocalyx may be a loose **slime layer** or a thick tough **capsule** (NCERT §8.4.1, p. 90). **Mesosomes** are infoldings of plasma membrane (vesicles, tubules, lamellae) that aid cell-wall formation, DNA replication & distribution, respiration, secretion, and increase surface area (NCERT §8.4.1, p. 90–91). **Chromatophores** are pigment-bearing membranous extensions in cyanobacteria (NCERT §8.4.1, p. 91).
- **Bacterial flagellum** has three parts — **filament, hook and basal body**; filament is the longest portion extending outward (NCERT §8.4.1, p. 91). **Pili** are elongated tubular protein structures and **fimbriae** are small bristle-like fibres; neither helps in motility — fimbriae help attachment to rocks/host tissues (NCERT §8.4.1, p. 91).
- **Prokaryotic ribosomes** are 70S (50S + 30S subunits), ~15 nm × 20 nm, sites of protein synthesis; several ribosomes on a single mRNA form a **polyribosome/ polysome** (NCERT §8.4.2, p. 91). **Inclusion bodies** are non-membrane-bound reserve stores in cytoplasm — phosphate granules, cyanophycean granules, glycogen granules; **gas vacuoles** occur in blue-green, purple and green photosynthetic bacteria (NCERT §8.4.2, p. 91).
- **Plasma membrane (fluid mosaic model, Singer & Nicolson, 1972):** phospholipid bilayer with polar heads outside and hydrophobic tails inside, plus cholesterol; integral proteins are partially/totally buried, peripheral lie on the surface; quasi-fluid lipid allows lateral movement of proteins (NCERT §8.5.1, p. 93–94, Figure 8.4). Human erythrocyte membrane is ~52% protein, ~40% lipid (NCERT §8.5.1, p. 93). Transport: **passive transport** (no energy — simple diffusion, **osmosis** for water); **active transport** uses ATP against gradient, e.g., Na^+/K^+ pump (NCERT §8.5.1, p. 94).
- **Cell wall** (fungi and plants): algal walls of cellulose, galactans, mannans, $CaCO_3$; other plants — cellulose, hemicellulose, pectins, proteins. **Primary wall** is growing (young cell); **secondary wall** forms later on the inner side. **Middle lamella** (mainly calcium pectate) glues neighbouring cells; **plasmodesmata** traverse wall + middle lamella connecting adjacent cytoplasms (NCERT §8.5.2, p. 94).

- **Endomembrane system** = ER + Golgi + lysosomes + vacuoles (mitochondria, chloroplasts, peroxisomes excluded because their functions are not coordinated with these) (NCERT §8.5.3, p. 94–95).
- **ER**: network of tubular structures; **RER** bears ribosomes — active in protein synthesis & secretion, continuous with outer nuclear membrane; **SER** lacks ribosomes — major site of lipid synthesis, makes steroidal hormones in animal cells (NCERT §8.5.3.1, p. 95, Figure 8.5).
- **Golgi apparatus** (Camillo Golgi, 1898): stacked flat disc-shaped **cisternae** (0.5–1.0 µm); convex **cis/forming face** receives ER vesicles, concave **trans/maturing face** ships them out; principal site of packaging and of glycoprotein/glycolipid formation (NCERT §8.5.3.2, p. 95–96, Figure 8.6).
- **Lysosomes** are golgi-derived membrane-bound vesicles rich in **hydrolytic enzymes** (lipases, proteases, carbohydrases — hydrolases) optimally active at acidic pH; digest carbohydrates, proteins, lipids and nucleic acids (NCERT §8.5.3.3, p. 96).
- **Vacuoles** are bound by a single membrane called **tonoplast**; in plant cells can occupy up to **90%** of cell volume; tonoplast actively transports ions/materials against gradient. Amoeba has **contractile vacuoles** for osmoregulation/excretion; protists form **food vacuoles** by engulfing food (NCERT §8.5.3.4, p. 96).
- **Mitochondria**: sausage-shaped, 0.2–1.0 µm diameter (avg. 0.5 µm) × 1.0–4.1 µm long; **double membrane** — outer is continuous limiting boundary, inner forms **cristae** (infoldings) towards the **matrix** which increases surface area; matrix has single circular DNA, RNAs, **70S ribosomes**; sites of aerobic respiration producing ATP — "**power houses of the cell**"; divide by **fission** (NCERT §8.5.4, p. 96–97, Figure 8.7).
- **Plastids** (in plant cells and euglenoides): **chloroplasts** (chlorophyll + carotenoid — photosynthesis), **chromoplasts** (fat-soluble carotene/xanthophyll — yellow/orange/red colour), **leucoplasts** (colourless storage) — **amyloplasts** (starch, e.g., potato), **elaioplasts** (oils/fats), **aleuroplasts** (proteins) (NCERT §8.5.5, p. 97–98). Chloroplast: 5–10 µm long, 2–4 µm wide; Chlamydomonas has 1, mesophyll cells 20–40; double-membraned; inner space = **stroma** containing enzymes, circular DNA, 70S ribosomes; flattened **thylakoids** stacked as **grana**, with **stroma lamellae** linking grana; thylakoid lumen inside (NCERT §8.5.5, p. 98, Figure 8.8).
- **Ribosomes** (George Palade, 1953): RNA + protein, no membrane. **Eukaryotic = 80S** (60S + 40S); **prokaryotic = 70S** (50S + 30S). 'S' = Svedberg's sedimentation coefficient (NCERT §8.5.6, p. 98, Figure 8.9).
- **Cytoskeleton**: network of microtubules, microfilaments and intermediate filaments — mechanical support, motility, shape maintenance (NCERT §8.5.7, p. 98).
- **Cilia & flagella**: hair-like outgrowths of cell membrane; cilia are short (oar-like), flagella longer (cell movement); eukaryotic flagella are structurally different from prokaryotic ones. Core = **axoneme** with **9 doublets of peripheral microtubules** + **1 central pair** = **9+2 array**; central pair enclosed by a central sheath connected to

peripheral doublets by **radial spokes** (nine of them); peripheral doublets linked by **interdoublet bridges/linkers**; arise from **basal bodies** (centriole-like) (NCERT §8.5.8, p. 99, Figure 8.10).

- **Centrosome & centrioles**: centrosome has two cylindrical centrioles lying perpendicular to each other in a cartwheel organisation, surrounded by pericentriolar material; each centriole = **9 peripheral fibrils of tubulin, each a triplet**; central proteinaceous **hub** linked to triplets by **radial spokes**; centrioles form basal bodies of cilia/flagella and the spindle apparatus in animal cell division (NCERT §8.5.9, p. 99–100).
- **Nucleus** (Robert Brown, 1831): bound by a double-membraned **nuclear envelope** with **perinuclear space** (10–50 nm); outer membrane is continuous with ER and bears ribosomes; **nuclear pores** (formed by fusion of the two membranes) allow RNA/protein exchange. **Nucleoplasm** holds **nucleolus** (non-membrane-bound, site of ribosomal RNA synthesis — larger/numerous in protein-active cells) and **chromatin** (DNA + histones + non-histone proteins + RNA) (NCERT §8.5.10, p. 100, Figure 8.11). A human cell has ~2 m of DNA across 46 (23 pairs) chromosomes (NCERT §8.5.10, p. 101).
- **Chromosomes**: have a primary constriction — the **centromere** — with disc-shaped **kinetochores**; by centromere position — **metacentric** (middle, equal arms), **sub-metacentric** (slightly off middle, one short + one long arm), **acrocentric** (near end, one very short + one very long arm), **telocentric** (terminal centromere). Secondary constrictions can give a small **satellite** fragment (NCERT §8.5.10, p. 101–102, Figures 8.12, 8.13).
- **Microbodies**: membrane-bound minute vesicles containing various enzymes; present in both plant and animal cells (NCERT §8.5.11, p. 102).

2.2 Definitions to memorise

Term	Definition	Page
Cell theory	All living organisms are composed of cells and products of cells; all cells arise from pre-existing cells	88
Plasmid	Small circular extra-genomic DNA in many bacteria, conferring phenotypic traits like antibiotic resistance	90
Gram positive / Gram negative	Bacteria that take up / do not take up the gram stain due to differences in cell envelopes	90
Mesosome	Specialised infolding of prokaryotic plasma membrane (vesicles, tubules, lamellae); aids cell-wall formation, DNA replication/ distribution, respiration, secretion, surface-area & enzyme content	90–91
Chromatophore	Pigment-containing membranous extensions of plasma membrane in cyanobacteria	91

Term	Definition	Page
Pili vs Fimbriae	Pili — elongated tubular protein structures; Fimbriae — small bristle-like fibres for attachment; neither aids motility	91
70S ribosome	Prokaryotic ribosome (50S + 30S subunits); ~15 × 20 nm; site of protein synthesis	91
Inclusion bodies	Non-membrane-bound cytoplasmic reserves in prokaryotes — phosphate, cyanophycean, glycogen granules	91
Fluid mosaic model	Singer & Nicolson (1972) — quasi-fluid phospholipid bilayer + cholesterol with integral/peripheral proteins moving laterally	94
Active transport	Energy-dependent (ATP) movement of ions/molecules against concentration gradient, e.g., Na^+/K^+ pump	94
Middle lamella	Layer mainly of calcium pectate that glues adjacent plant cells	94
Plasmodesmata	Cytoplasmic bridges traversing cell wall and middle lamella, connecting cytoplasm of neighbouring cells	94
Endomembrane system	Coordinated ER + Golgi + lysosomes + vacuoles (excludes mitochondria, chloroplasts, peroxisomes)	94–95
Cisternae (Golgi)	Flat, disc-shaped sacs (0.5–1.0 µm) stacked in Golgi; cis = forming face (convex), trans = maturing face (concave)	95–96
Tonoplast	Single membrane bounding the plant vacuole; actively transports ions against gradient	96
Cristae	Infoldings of inner mitochondrial membrane that increase surface area	97
Grana / Stroma lamellae	Stacks of thylakoids in chloroplast / flat membranous tubules connecting thylakoids of different grana	98
80S ribosome	Eukaryotic cytoplasmic ribosome (60S + 40S subunits); 'S' = Svedberg's sedimentation coefficient	98
Axoneme (9+2)	Core of cilium/flagellum — 9 peripheral microtubule doublets + 1 central pair, with radial spokes and central sheath	99
Centromere	Primary constriction of a chromosome bearing kinetochores; holds two chromatids	101
Satellite	Small fragment produced by a non-staining secondary constriction on certain chromosomes	102
Microbodies	Membrane-bound minute vesicles in both plant and animal cells, containing various enzymes	102

2.3 Diagrams / processes to remember

- **Figure 8.1, p. 89** — different cell shapes: biconcave RBCs, amoeboid WBCs, long-narrow columnar epithelial cells, branched nerve cell, elongated tracheid, round/oval mesophyll cells. Classic distractor set for "Which cell is amoeboid?" type questions.

- **Figure 8.2, p. 90** — relative-size comparison: typical eukaryotic cell (10–20 µm) vs typical bacterium (1–2 µm) vs PPLO (~0.1 µm) vs viruses (0.02–0.2 µm).
- **Figure 8.3, p. 92** — labelled (a) plant cell with cell wall, middle lamella, plasmodesmata, chloroplast, large vacuole; (b) animal cell with microvilli, centriole, no cell wall/plastid. Note: plant cell shows all the endomembrane organelles too.
- **Figure 8.4, p. 93** — fluid mosaic model labels: phospholipid bilayer, integral protein, peripheral protein, cholesterol, sugar (glycoprotein/glycolipid moieties).
- **Figure 8.5, p. 95** — nuclear envelope continuous with RER; ribosomes studded on RER; smooth ER without ribosomes; nuclear pore visible.
- **Figure 8.6, p. 95** — Golgi cisternae stacked with vesicles pinching off.
- **Figure 8.7, p. 97** — mitochondrion (LS): outer membrane, inner membrane, inter-membrane space, matrix, crista.
- **Figure 8.8, p. 98** — chloroplast (sectional): outer + inner membranes, stroma, granum (stack of thylakoids), individual thylakoid, stroma lamella.
- **Figure 8.9, p. 98** — ribosome shown as larger (60S/50S) + smaller (40S/30S) subunit.
- **Figure 8.10, p. 99** — cross-section of cilium/flagellum showing 9+2 array: peripheral doublets, central pair, central sheath, radial spokes, interdoublet bridge, plasma membrane sheath.
- **Figure 8.11, p. 100** — nucleus: nuclear membrane (double), nuclear pore, nucleolus, nucleoplasm.
- **Figure 8.12, p. 101** — chromosome with two chromatids and a kinetochore at centromere.
- **Figure 8.13, p. 101** — four chromosome types side-by-side: metacentric (V-shaped, equal arms, satellite + secondary constriction labelled), sub-metacentric (L-shaped), acrocentric (J-shaped — one very short arm), telocentric (rod-shaped — terminal centromere).

2.4 Common confusions / NTA trap points

- **Robert Brown discovered the nucleus, NOT the cell.** Leeuwenhoek first saw a live cell. (NCERT §8.1, p. 87 — also tested in NCERT exercise Q1.)
- **Mesosome ≠ chromatophore.** Both are infoldings of prokaryotic plasma membrane, but chromatophores are pigmented (cyanobacteria); mesosomes are general (NCERT §8.4.1, p. 90–91).
- **Pili vs fimbriae vs flagella.** Only **flagella** are motile; **pili** and **fimbriae** are non-motile surface structures — fimbriae help attachment (NCERT §8.4.1, p. 91).
- **Ribosome S-values.** 70S = prokaryotic AND mitochondrial AND chloroplast ribosomes; 80S = eukaryotic cytoplasmic. 'S' is Svedberg sedimentation coefficient — not the sum of subunits (50 + 30 ≠ 80; they're not additive) (NCERT §8.4.2, p. 91; §8.5.6, p. 98).

- **Endomembrane system excludes mitochondria, chloroplasts and peroxisomes** even though they are membrane-bound (NCERT §8.5.3, p. 95).
- **Cristae vs Cisternae vs Thylakoids** — classic match-the-following: cristae = infoldings in mitochondria; cisternae = disc-shaped sacs in Golgi; thylakoids = flat membranous sacs in stroma of chloroplast (NCERT exercise Q3, p. 103).
- **Tonoplast** is the vacuolar membrane, not the plasma membrane (NCERT §8.5.3.4, p. 96).
- **Centriole is found in animal cells; centrioles are absent in almost all plant cells.** Plant cells have plastids and large vacuoles instead (NCERT §8.5, p. 91).

🎯 Practice MCQs

Q1. Who among the following proposed that cells arise only from pre-existing cells, completing the formulation of the cell theory?

A. Matthias Schleiden

B. Theodore Schwann

C. Rudolf Virchow

D. Robert Brown

Q2. The smallest known cells, mycoplasmas, are about

A. 0.3 µm in length

B. 3 µm in length

C. 0.3 mm in length

D. 7.0 µm in diameter

Q3. The cell envelope of a typical bacterium consists of three layers. The correct sequence from outside to inside is:

A. Cell wall → glycocalyx → plasma membrane

B. Glycocalyx → cell wall → plasma membrane

C. Plasma membrane → cell wall → glycocalyx

D. Glycocalyx → plasma membrane → cell wall

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📊 PYQ Alignment

This chapter is one of the most heavily tested units in CUET (UG) Biology — past papers (2023–2025) typically draw 3–5 direct questions from it each year, covering cell-theory dates and proponents, Gram +/– envelope structure, mesosome functions, 70S vs 80S ribosomes, fluid-mosaic terminology, the cristae–cisternae–thylakoid match, double-membrane organelle lists, the 9+2 axoneme, and chromosome classification by centromere position. Statement-based "which of the following is correct" and match-the-following formats dominate, so memorise the figures (8.3, 8.7, 8.8, 8.10, 8.13) along with the exact NCERT sentences.

Cell - The Unit of Life appeared in CUET (UG) Biology across 2 cycle(s) — 2 question(s) total. The questions below were extracted from official CUET (UG) papers and matched to this chapter by topic. See `/pyq/biology` for the full PYQ archive.

CUET 2023 — Actual PYQs from this chapter

Q.13 (CUET 2023) Match List-I with List-II List-I (A) Ribosome (B) Histone (C) DNA polymerase (D) RNA polymerase List-II (I) Replication (II) Transcription (III) Translation (IV) Nucleosome

- A) A-IV, B-III, C-II, D-IV
- B) A-III, B-I, C-II, D-IV
- C) A-I, B-III, C-IV, D-II
- D) A-III, B-IV, C-I, D-II

Tests: aligns with chapter content Answer: Not in extracted key — verify against official NTA key

CUET 2024 — Actual PYQs from this chapter

Q.3 (CUET 2024) Primary Endosperm Nucleus is the product of:

- A) Double fusion
- B) Triple fusion
- C) Parthenogenesis
- D) Apomixis

Tests: aligns with chapter content Answer: Not in extracted key — verify against official NTA key