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Cell The Unit of Life Class 11 Notes | CBSE Biology Chapter 8

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Cell The Unit of Life Class 11 Notes | CBSE Biology Chapter 8

Cell – The Unit of Life is Chapter 8 of CBSE Class 11 Biology, and it is the chapter that everything else in biology quietly depends on. Every leaf, every muscle, every thought you have is the work of cells — the smallest units that can be called *alive*. Master this chapter and the rest of cell biology, plant physiology, and human physiology suddenly start to make sense.

By the end of these notes you will be able to state the cell theory, tell a prokaryotic cell from a eukaryotic one in a single glance, describe every major organelle and its job, and answer any board or NEET question on cell structure with confidence. This is a high-weightage chapter carrying roughly 6–8 marks in boards and forming the foundation for Biomolecules, Cell Cycle, and all of physiology.

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Key Concepts

1. The Cell and Cell Theory

A **cell** is the basic structural and functional unit of all living organisms — the smallest unit capable of independent existence and of carrying out all life functions. Robert Hooke first observed dead cork cells in 1665, and Anton von Leeuwenhoek first saw living cells.

The **cell theory** was proposed by Matthias Schleiden (botanist, 1838) and Theodor Schwann (zoologist, 1839). It was later refined by Rudolf Virchow (1855), who gave the famous line *Omnis cellula-e cellula* — every cell arises from a pre-existing cell.

The Cell Theory states:

- All living organisms are composed of cells and products of cells.
- All cells arise from pre-existing cells (Virchow's contribution).

Exception: Viruses are not made of cells, so the cell theory does not strictly apply to them.

2. Overview: What All Cells Share

Despite enormous variety in shape and size, every cell shares three basics: a covering **plasma membrane**, a jelly-like **cytoplasm** where reactions happen, and **genetic material (DNA)** that controls the cell.

- The smallest cells are **Mycoplasma** (about 0.3 μm), the smallest living cells known.
- Bacteria are 3–5 μm ; a typical eukaryotic cell is much larger.
- The largest isolated single cell is the **egg of an ostrich**.
- The longest cells are **nerve cells**.

On this basis cells are grouped into two great types: **prokaryotic** (no true nucleus) and **eukaryotic** (true, membrane-bound nucleus).

3. Prokaryotic Cells

Prokaryotic cells are found in **bacteria**, **blue-green algae (cyanobacteria)**, **mycoplasma** and **PPLO**. They are generally smaller and multiply more rapidly than eukaryotic cells.

Their defining feature is the absence of a true, membrane-bound nucleus — the genetic material lies free in the cytoplasm in a region called the **nucleoid**. They also lack membrane-bound organelles like mitochondria, plastids, ER and Golgi.

Key features of a prokaryotic cell

- **Genetic material:** single, circular, naked DNA in the nucleoid; no nuclear membrane.
- **Plasmids:** small extra-chromosomal circular DNA that gives traits like antibiotic resistance.
- **Ribosomes:** 70S type (smaller than eukaryotic 80S).
- **Mesosome:** infolding of the plasma membrane that helps in respiration, secretion and DNA replication.
- **Cell envelope:** a three-layered covering — glycocalyx, cell wall, and plasma membrane.

Cell Envelope and Bacterial Types

The bacterial cell wall is made of **peptidoglycan**. Based on the Gram-staining response (developed by Gram), bacteria are **Gram-positive** (retain the stain) or **Gram-negative** (do not). Some bacteria also have **flagella** for motility and **pili/fimbriae** for attachment.

[DIAGRAM: A bacterial cell showing glycocalyx, cell wall, plasma membrane, nucleoid, ribosomes, mesosome, flagellum and pili.]

4. Eukaryotic Cells

Eukaryotic cells are found in **protists, fungi, plants and animals**. They have a true membrane-bound nucleus and a variety of membrane-bound organelles, allowing a clear division of labour inside the cell.

Their genetic material is organised into **chromosomes**, and the ribosomes are of the larger **80S** type.

Plant cell vs Animal cell

Feature	Plant Cell	Animal Cell
Cell wall	Present (cellulose)	Absent
Plastids	Present (e.g. chloroplast)	Absent
Vacuole	Large, central	Small or absent
Centriole / Centrosome	Usually absent	Present
Lysosomes	Rare	Common

5. Cell Membrane (Plasma Membrane)

The **plasma membrane** is the living, selectively permeable boundary of the cell. The most accepted model is the **fluid mosaic model** proposed by Singer and Nicolson (1972).

It is mainly a **lipid bilayer** (phospholipids arranged with polar heads outside and hydrophobic tails inside) with proteins floating in it. Because the lipids and proteins can move laterally, the membrane is described as *fluid* — this fluidity is vital for growth, division and secretion.

Transport across the membrane

- **Passive transport:** movement down a concentration gradient without energy — by simple diffusion or osmosis.
- **Facilitated diffusion:** down the gradient but with the help of carrier/channel proteins.
- **Active transport:** movement against the gradient using ATP (e.g. the $\text{Na}^+\text{--K}^+$ pump).

6. Cell Wall

The **cell wall** is a non-living, rigid outer covering found in plant cells, fungi, algae and prokaryotes (but not in animal cells). It gives shape, mechanical strength, and protection against mechanical and osmotic stress.

- In **plants** it is made of **cellulose, hemicellulose, pectin and proteins**; in **fungi** of **chitin**.
- The **middle lamella** (made of calcium pectate) cements adjacent cells together.
- The young cell has a thin, elastic **primary wall**; on maturity a thick **secondary wall** forms.

- **Plasmodesmata** are cytoplasmic bridges connecting neighbouring cells.
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7. Endomembrane System

Several organelles work together as a coordinated unit called the **endomembrane system**: the **endoplasmic reticulum**, **Golgi apparatus**, **lysosomes** and **vacuoles**. (Mitochondria, chloroplasts and peroxisomes are not included, as they are not functionally coordinated with these.)

(a) Endoplasmic Reticulum (ER)

The ER is a network of membrane-bound tubules and sheets continuous with the nuclear membrane.

- **Rough ER (RER)**: studded with ribosomes; active in **protein synthesis and secretion**.
- **Smooth ER (SER)**: no ribosomes; site of **lipid and steroid synthesis** and detoxification.

(b) Golgi Apparatus

Discovered by Camillo Golgi, it is a stack of flattened, disc-shaped **cisternae**. It packages, modifies and dispatches materials — the cell's "post office." It has a **cis (forming) face** near the ER and a **trans (maturing) face**. It is the main site of **glycoprotein and glycolipid formation**.

(c) Lysosomes

Lysosomes are membrane-bound vesicles rich in **hydrolytic (digestive) enzymes** that work best in an acidic medium. They digest worn-out organelles, food and foreign material — earning the nickname "**suicidal bags**" of the cell.

(d) Vacuoles

A vacuole is a membrane-bound space (its membrane is the **tonoplast**) filled with cell sap. In plants it can occupy up to 90% of the cell volume and maintains **turgidity and osmotic pressure**.

8. Mitochondria

Mitochondria are double-membrane organelles known as the "**powerhouse of the cell**" because they are the site of **aerobic respiration** and produce ATP.

- The **outer membrane** is smooth; the **inner membrane** folds inward to form **cristae**, increasing surface area for ATP synthesis.
 - The inner space is the **matrix**, which contains enzymes, ribosomes (70S) and its own circular DNA.
 - Because they have their own DNA and ribosomes and divide on their own, mitochondria are called **semi-autonomous organelles**.
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9. Plastids

Plastids are double-membrane organelles found only in plant cells and some protists. They are classified by the pigment they carry.

- **Chloroplasts:** contain green **chlorophyll**; site of **photosynthesis**. Inside are stacks of **thylakoids (grana)** embedded in a fluid **stroma** with 70S ribosomes and DNA.
- **Chromoplasts:** contain fat-soluble carotenoid pigments (yellow, orange, red) — give colour to flowers and fruits.
- **Leucoplasts:** colourless plastids that store food — amyloplasts (starch), elaioplasts (oils/fats), aleuroplasts (proteins).

Like mitochondria, chloroplasts are **semi-autonomous** (own DNA + 70S ribosomes).

10. Ribosomes

Ribosomes are tiny, non-membranous granules made of **rRNA and proteins**; they are the site of **protein synthesis**. They were discovered by George Palade.

- **80S** ribosomes (60S + 40S subunits) in the cytoplasm of eukaryotes.
 - **70S** ribosomes (50S + 30S subunits) in prokaryotes and in mitochondria/chloroplasts.
 - Several ribosomes on one mRNA form a **polysome (polyribosome)**.
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11. Microbodies, Cytoskeleton, Cilia, Flagella & Centrosome

(a) Microbodies

Membrane-bound minute vesicles containing enzymes — e.g. **peroxisomes** and **glyoxysomes**, found in both plant and animal cells.

(b) Cytoskeleton

A network of proteinaceous filaments — **microtubules, microfilaments and intermediate filaments** — that gives the cell mechanical support, shape, and helps in movement.

(c) Cilia and Flagella

Hair-like projections of the plasma membrane that help in movement. Both have a core called the **axoneme** with a **9 + 2 arrangement** of microtubules (9 peripheral pairs + 2 central). **Cilia** are small and numerous; **flagella** are longer and fewer.

(d) Centrosome and Centrioles

The centrosome contains two cylindrical **centrioles** arranged at right angles, each with a **9 + 0** (cartwheel) arrangement of microtubule triplets. Centrioles form the **spindle fibres during cell division** and the basal body of cilia and flagella.

12. Nucleus and Chromosomes

The **nucleus**, described by Robert Brown (1831), is the control centre of the cell. It is bound by a double **nuclear envelope** with **nuclear pores** that allow exchange of material with the cytoplasm.

- The fluid inside is the **nucleoplasm**, containing the nucleolus and chromatin.
- The **nucleolus** is a non-membranous structure that is the site of **ribosome (rRNA) synthesis**.
- **Chromatin** is a network of DNA + histone proteins; it condenses into **chromosomes** during cell division.

Chromosome Structure

Each chromosome has a primary constriction called the **centromere**, bearing disc-shaped **kinetochores**. Based on the centromere's position, chromosomes are classified as:

Type	Position of Centromere	Shape
Metacentric	Middle	Forms two equal arms (V-shaped)
Sub-metacentric	Slightly away from middle	Unequal arms (L-shaped)
Acrocentric	Near the end	One very long, one very short arm (J-shaped)
Telocentric	At the tip	Rod-shaped

A chromosome with a secondary constriction bearing a **satellite** is called a **satellite chromosome (SAT chromosome)**.

Weightage in Board & Entrance Exams

Exam	Typical Weightage	Most-Tested Areas
CBSE Board (Class 11)	6–8 marks	Cell theory, prokaryote vs eukaryote, organelle functions, plant vs animal cell
NEET	3–4 questions	Ribosomes (70S/80S), mitochondria, plastids, fluid mosaic model, cell wall
State CETs	2–3 questions	Cell organelles, nucleus, semi-autonomous organelles

[TABLE: Question-type split — VSA (1 mark): definitions, scientists, organelle functions; SA (2–3 marks): prokaryote vs eukaryote, plant vs animal cell, endomembrane system; LA (5 marks): structure of mitochondria/chloroplast/nucleus with labelled diagram.]

Important Definitions

Term	Definition
Cell	Basic structural and functional unit of life; smallest unit capable of independent existence
Cell theory	All organisms are made of cells, and all cells arise from pre-existing cells
Nucleoid	Region of a prokaryotic cell where the naked DNA lies, with no nuclear membrane
Mesosome	Infolding of the plasma membrane in bacteria, aiding respiration and DNA replication
Fluid mosaic model	Membrane model (Singer & Nicolson) of proteins floating in a fluid lipid bilayer
Cristae	Infoldings of the inner mitochondrial membrane that increase surface area for ATP synthesis
Grana	Stacks of thylakoids in a chloroplast where the light reactions of photosynthesis occur
Semi-autonomous organelle	Organelle with its own DNA and 70S ribosomes (mitochondria, chloroplast)
Tonoplast	Single membrane surrounding a plant vacuole
Centromere	Primary constriction of a chromosome bearing the kinetochore, holding sister chromatids

Solved/Illustrative Explanations

Example 1

Why are mitochondria and chloroplasts called semi-autonomous organelles?

Answer: Because each has its **own circular DNA and 70S ribosomes** and can synthesise some of its own proteins and divide by fission — yet they still depend on the nucleus for most proteins, so they are only *semi*-autonomous.

Example 2

A scientist observes a cell under the microscope and finds no nuclear membrane and 70S ribosomes. What type of cell is it?

Answer: The absence of a nuclear membrane (DNA lies in a nucleoid) and the presence of 70S ribosomes are signatures of a **prokaryotic cell**, e.g. a bacterium.

Example 3

Why are lysosomes called the “suicidal bags” of the cell?

Answer: Lysosomes contain powerful **hydrolytic enzymes**. If their membrane ruptures, these enzymes are released into the cytoplasm and digest (autolyse) the cell's own contents — hence the name.

Example 4

Distinguish the 9 + 2 and 9 + 0 microtubule arrangements and where each is found.

Answer: The **9 + 2** arrangement (9 peripheral doublets + 2 central microtubules) is found in the **axoneme of cilia and flagella**. The **9 + 0** arrangement (9 peripheral triplets, no central tubule) is found in **centrioles and basal bodies**.

Example 5

State one function each of the rough ER and smooth ER.

Answer: Rough ER (with ribosomes) is the site of **protein synthesis and secretion**; smooth ER is the site of **lipid and steroid synthesis** and detoxification.

Example 6

Name the organelle responsible for packaging and dispatching cell products, and describe its two faces.

Answer: The **Golgi apparatus**. Its **cis (forming) face** lies near the ER and receives material; its **trans (maturing) face** packages and releases the modified products as vesicles.

Important Questions for Board Exams

1-Mark Questions (VSA)

1. Who proposed the cell theory and who modified it later?
2. Name the smallest living cell known.
3. What is the chemical nature of the bacterial cell wall?
4. Which organelle is called the “powerhouse of the cell”?
5. What is the function of the nucleolus?

2–3-Mark Questions (SA)

1. Differentiate between prokaryotic and eukaryotic cells (any three points).
2. Explain the fluid mosaic model of the plasma membrane.
3. Distinguish between rough and smooth endoplasmic reticulum with their functions.

4. Why are mitochondria and plastids called semi-autonomous organelles?

5-Mark Questions (LA)

1. Describe the structure of a mitochondrion with a labelled diagram and explain its role in respiration.
 2. Describe the structure of a chloroplast and explain the function of grana and stroma.
 3. Draw a well-labelled diagram of an animal cell and describe the structure and function of the nucleus.
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Quick Revision Points

- Cell theory: Schleiden & Schwann; modified by Virchow (Omnis cellula-e cellula)
 - Mycoplasma = smallest living cell; ostrich egg = largest single cell; nerve cell = longest
 - Prokaryotes: no nuclear membrane, nucleoid, 70S ribosomes, mesosome, peptidoglycan wall
 - Eukaryotes: true nucleus, membrane-bound organelles, 80S ribosomes, chromosomes
 - Plasma membrane: fluid mosaic model (Singer & Nicolson); selectively permeable lipid bilayer
 - Cell wall: cellulose in plants, chitin in fungi; middle lamella of calcium pectate
 - Endomembrane system: ER, Golgi, lysosomes, vacuoles
 - Mitochondria (cristae, matrix) and chloroplast (grana, stroma) = semi-autonomous, 70S
 - Ribosomes: 80S (eukaryote cytoplasm), 70S (prokaryote/organelle); site of protein synthesis
 - Cilia/flagella axoneme = $9 + 2$; centriole = $9 + 0$
 - Nucleus: Robert Brown; nucleolus makes rRNA; chromosome types by centromere position
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Next Chapter: Chapter 9 — Biomolecules



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