CLASS 9 SCIENCE

Chapter 2 Notes

Cell: The Building Block of Life

Chapter focus

Cells are the basic structural and functional units of life. This chapter explains how cells are studied, their boundaries and internal organelles, movement of substances, differences among bacterial, plant and animal cells, cell division and the Cell Theory.

1. Cell - The Basic Unit of Life

- All living organisms are made up of cells.
- Unicellular organisms, such as bacteria and yeast, consist of one cell.
- Multicellular organisms, such as plants, fish, birds and humans, consist of many cells working together.
- Similar cells performing similar functions form tissues; tissues form organs; organs work together in organ systems.

Organisation in living beings

Cell → Tissue → Organ → Organ system → Organism

2. How Do We Study Cells?

Most cells are too small to be seen clearly with the unaided eye. The limit of resolution of the human eye is about 0.1 mm when viewed from about 25 cm.

Tool / idea	Key point
Magnification	Makes an object appear larger.
Resolution	Ability to distinguish two close points as separate; a measure of clarity.
Contrast	Difference in brightness between different parts of an object.
Light microscope	Uses visible light and lenses; school microscopes use different objective lenses.
Electron microscope	Uses a beam of electrons and can reveal cell details at the nanometre scale.

Robert Hooke

- In 1665, Robert Hooke observed a thin slice of cork using a self-designed microscope.
- He saw small box-like compartments and named them 'cells'.

Estimating the size of an onion peel cell

Formula

Estimated cell size = Diameter of visible field (in µm) ÷ Number of cells along the diameter

- 1 mm = 1000 µm.
- Example: 5 mm field = 5000 µm. If 25 cells fit across it, estimated size = 5000 ÷ 25 = 200 µm.
- Total microscope magnification = eyepiece magnification × objective magnification. Example: 10X × 10X = 100X.

3. Cell Membrane - Universal Feature of a Cell

- The cell membrane, also called the plasma membrane, is a thin boundary around the cell.
- It protects the cell contents and gives the cell its individuality.
- It is selectively permeable: some substances can cross it while others are restricted.

Diffusion and Osmosis

Process	Meaning	Membrane needed?
Diffusion	Net movement of particles from higher concentration to lower concentration.	No
Osmosis	Diffusion of water across a selectively permeable membrane.	Yes

Potato experiment

- Potato in plain water swells and gains weight.
- Potato in concentrated salt/sugar solution shrinks and loses weight.
- Reason: water moves across cell membranes according to the concentration difference.

Solution	Outside solute concentration	General effect on cell
Isotonic	Equal to inside	No net change in concentration balance
Hypotonic	Lower than inside	Water tends to enter; cell swells
Hypertonic	Higher than inside	Water tends to leave; cell shrinks

Fluid-mosaic model of cell membrane

- The membrane is about 7-10 nm thick and is made mainly of lipids and proteins.
- It contains a lipid bilayer with water-attracting heads outward and water-repelling tails inward.
- Membrane molecules can move sideways, flip and rotate, so the membrane is fluid.
- Embedded proteins act like gatekeepers for movement of substances.
- Its tile-like arrangement gives the name 'mosaic' model.

4. Cell Wall - The Outer Covering

- Plant, fungal and bacterial cells have a cell wall outside the cell membrane.
- Plant cell walls provide rigidity, protection, shape and support.
- The plant cell wall is permeable and is mainly made of cellulose.
- Cellulose is a carbohydrate made of many glucose units; in our diet it acts as roughage.
- Animal cells do not have a cell wall, so they are more flexible and can change shape more easily.

Plant cell in concentrated sugar solution
Water leaves by osmosis. The inner cell contents shrink and the cell membrane pulls away from the rigid cell wall, while the outer cell shape is maintained.

5. The Cell Interior - A Coordinated Working System

- Most cells have a plasma membrane, cytoplasm and genetic material.
- In eukaryotic cells, the cytoplasm contains membrane-bound organelles that perform specialised functions.
- A cell can be compared to a tiny living factory in which different parts perform different jobs but work together.

6. Prokaryotic and Eukaryotic Cells

Feature	Prokaryotic cell	Eukaryotic cell
Nucleus	No well-defined nucleus; nucleoid present	Well-defined membrane-bound nucleus
Typical diameter	1-10 µm	10-100 µm
Organisation	Usually unicellular	May be unicellular or multicellular
Membrane-bound organelles	Absent	Present
Example in chapter	Bacterial cell	Plant and animal cells

Nucleoid
In prokaryotic cells, DNA is present in a region called the nucleoid rather than inside a membrane-bound nucleus.

7. Major Cell Organelles and Their Functions

Organelle	Main function / important point
Nucleus	Contains genetic information; coordinates cell activities.
Nucleolus	Site where ribosomal subunits are synthesised.
Ribosomes	Sites of protein synthesis; free in cytoplasm or attached to ER.
Rough ER (RER)	Has ribosomes; mainly involved in protein synthesis and secretion.
Smooth ER (SER)	Lacks ribosomes; involved in synthesis and storage of fats and hormones.
Golgi apparatus	Modifies, sorts and packages proteins/lipids into vesicles for transport, secretion or lysosome formation.
Lysosomes	Enzyme-filled sacs that break down wastes, unwanted materials and damaged cell parts.
Mitochondria	Release energy through cellular respiration; ATP stores usable cellular energy.
Plastids	Plant organelles involved in food synthesis, colour or food storage.
Vacuole	Stores water, minerals, sugars and wastes; large central vacuole helps keep plant cells firm.

8. Nucleus - House of Coded Instructions

- The nucleus is surrounded by a double-layered nuclear membrane with pores.
- Nuclear pores allow transfer of material between nucleus and cytoplasm.
- Chromosomes contain DNA and specific proteins.
- DNA carries genetic information; functional segments of DNA are called genes.
- In a non-dividing cell, DNA occurs as chromatin, an entangled thread-like mass.
- Before cell division, chromatin becomes organised into chromosomes.

Special case: Human RBCs

Mature human red blood cells do not have a nucleus. This provides more space for haemoglobin and helps them carry more oxygen. They cannot repair or divide themselves and survive for about 120 days.

9. ER → Golgi: Manufacturing, Packaging and Transport

Protein pathway

Ribosome on RER → protein enters/associates with ER pathway → Golgi apparatus modifies, sorts and packages → vesicles carry material for transport or secretion.

RER	SER
Ribosomes present on surface	No ribosomes on surface
Appears rough	Appears smooth
Protein synthesis and secretion	Synthesis/storage of fats and hormones

10. Lysosomes - The Clean-up System

- Lysosomes are single membrane-bound sacs containing digestive enzymes.
- They break down unwanted proteins, carbohydrates, fats and damaged cell components.
- Breakdown products may be released into the cytoplasm and reused.
- The lysosomal enzymes in sperm help break down the egg's outer layer during fertilisation.

11. Mitochondria - Powerhouses of the Cell

- Mitochondria supply energy needed for most cellular activities.
- They have two membranes: a smooth porous outer membrane and a folded inner membrane.
- Inner folds are called cristae; they increase surface area for reactions involved in energy production.
- During cellular respiration, glucose and other molecules are broken down to release energy.
- Energy is stored in ATP (Adenosine Triphosphate), called the energy currency of the cell.
- Mitochondria possess their own DNA and ribosomes.

12. Plastids - Special Organelles of Plant Cells

Type	Pigment / feature	Main role
Chloroplast	Contains chlorophyll	Photosynthesis; absorbs light energy
Chromoplast	Yellow, orange or red pigments	Gives bright colours to flowers/fruits; helps attract pollinators and seed-dispersing animals
Leucoplast	Colourless	Stores food such as starch, oils or proteins

- Chloroplasts are double-membrane-bound.
- The inner semi-fluid material is called stroma.
- Sugars produced during photosynthesis and starch granules can be stored in the stroma.
- Like mitochondria, plastids have their own DNA and ribosomes and can make some of their own proteins.

13. Vacuoles - Storage and Support

- A mature plant cell usually has one large central vacuole surrounded by a selectively permeable membrane.
- It contains cell sap and stores water, minerals, sugars and waste materials.
- Water in the vacuole helps maintain internal pressure and keeps the plant cell firm.
- When water is insufficient, vacuoles lose water, cells become less firm and the plant wilts.
- Animal-cell vacuoles, when present, are generally smaller and provide temporary storage.

14. Bacterial, Plant and Animal Cells - Quick Comparison

Feature	Bacterial	Plant	Animal
Cell membrane	Present	Present	Present
Cell wall	Present	Present	Absent
Cytoplasm	Present	Present	Present
Well-defined nucleus	Absent	Present	Present
Nucleoid	Present	Absent	Absent
Membrane-bound organelles	Absent	Present	Present
Plastids	Absent	Present	Absent
Large central vacuole	Absent	Usually present	Absent; smaller vacuoles may occur

15. How Do Normal Cells Grow and Divide?

- Cells grow only up to a certain size; growth of an organism largely occurs by increase in cell number through cell division.
- Cell division forms new cells from pre-existing cells.
- It supports growth, repair of damaged tissues and reproduction.
- In eukaryotic cells, division occurs in a controlled and orderly manner through the cell cycle.

16. Mitosis and Meiosis

Feature	Mitosis	Meiosis
Main importance	Growth, repair, maintenance and asexual reproduction	Sexual reproduction and genetic diversity
Number of divisions	One	Two successive divisions
Daughter cells formed	Two	Four
Chromosome number	Same as parent cell	Half the parent-cell number
Genetic relation	Daughter cells are genetically identical to parent cell	Gametes contribute to variation
Where highlighted	Body growth/repair	Reproductive organs; gamete formation

- In humans, meiosis occurs in cells of testes to produce sperm and ovaries to produce eggs.
- In plants, meiosis occurs in anthers and ovaries in connection with formation of reproductive cells.
- During fertilisation, fusion of gametes restores the original chromosome number.

17. Cell Culture

- Cell culture means growing plant or animal cells outside the body under special conditions.
- Cells are kept in a nutrient-rich medium with suitable temperature, pH, moisture and sterile conditions.
- It is useful for studying cells and for producing biochemicals, food, medicines and vaccines.

18. Cell Theory - The Unifying Principle of Biology

Scientist	Contribution
Matthias Schleiden (1838)	Reported that all plants are made up of cells.
Theodor Schwann (1839)	Found that all animals are made up of cells.
Rudolf Virchow (1855)	Stated that new cells arise only from pre-existing cells.

Classical Cell Theory

1. All living organisms are made up of one or more cells.
2. The cell is the basic unit of structure and function in living beings.
3. All cells arise from pre-existing cells.

19. Do Cells Grow and Reproduce Forever?

- Normal cells grow and divide in a controlled manner, perform their functions and eventually die.
- Dead cells are replaced by new cells performing the same function.
- Many animal cells stop dividing when they contact neighbouring cells; this is called contact inhibition.
- Cancer cells can lose this control and divide uncontrollably, producing tumours.
- Programmed Cell Death (PCD) is a genetically regulated process important for normal development, cellular quality control and immune function.

Example of PCD

During embryo development, programmed cell death removes cells between developing digits and helps form separate fingers.

20. Scientists and Important Extensions

Scientist / work	Why it matters
Camillo Golgi	Observed the structure later named Golgi apparatus; electron microscopy eventually confirmed it clearly.
Arun Kumar Sharma	Indian botanist known for chromosome research, plant taxonomy, evolution and useful laboratory methods.
Gottlieb Haberlandt	Proposed the idea behind plant-cell totipotency, laying foundations for plant tissue culture technology.
J. Craig Venter and team (2010)	Used chemically synthesised bacterial DNA in an existing cell whose DNA had been removed; the cell then grew and divided according to the inserted DNA.

Important clarification
The 2010 experiment did not create a completely new cell from non-living material. The DNA was synthetic, but the remaining cell components came from an existing living cell.

21. Quick Revision - Key Terms

Term	Meaning
Cell	Basic structural and functional unit of life.
Plasma membrane	Selectively permeable boundary surrounding a cell.
Cell wall	Rigid outer covering present in plants, fungi and bacteria.
Cytoplasm	Semi-fluid, jelly-like substance inside the cell.
Organelle	Specialised sub-cellular component performing a specific function.
Nucleoid	Region containing genetic material in a prokaryotic cell.
Osmosis	Movement/diffusion of water across a selectively permeable membrane.
Diffusion	Net movement of particles from higher to lower concentration.
ATP	Energy-carrying molecule used for cellular activities.
Gene	Functional segment of DNA.
Mitosis	Division producing two genetically identical daughter cells.
Meiosis	Two-step division producing four cells with half the chromosome number.
Contact inhibition	Control in many animal cells that stops division on contact with neighbouring cells.

22. Common Misconceptions

Misconception	Correct idea
All cells have a cell wall.	All cells have a cell membrane; cell walls occur in plants, fungi and bacteria, not animal cells.
Osmosis and diffusion are exactly the same.	Osmosis specifically involves water moving across a selectively permeable membrane.
All cells have a well-defined nucleus.	Prokaryotic cells have a nucleoid instead of a membrane-bound nucleus.
All plastids are green.	Chloroplasts are green; chromoplasts may be yellow/orange/red; leucoplasts are colourless.
Mitosis and meiosis produce the same cells.	Mitosis forms two genetically identical cells; meiosis forms four cells with half the chromosome number.
Cells divide forever normally.	Normal cell growth and division are controlled; cells also age and die.

23. Exam-Oriented Self-Check Questions

1. Why is the cell called the structural and functional unit of life?
2. What is the limit of resolution of the human eye?
3. Differentiate between magnification and resolution.
4. Define diffusion and osmosis.
5. Why does a potato piece swell in plain water but shrink in concentrated salt solution?
6. Differentiate between cell membrane and cell wall.
7. Compare prokaryotic and eukaryotic cells.
8. Write the functions of nucleus, ribosomes, ER, Golgi apparatus and lysosomes.
9. Why are mitochondria called the powerhouses of the cell?
10. Name the three main types of plastids and state their functions.
11. How does a large central vacuole help a plant cell?
12. Differentiate between mitosis and meiosis.
13. State the three points of the classical Cell Theory.
14. What is contact inhibition? How is it related to uncontrolled cell division?
15. Explain why mitochondria and chloroplasts are considered unusual organelles.

24. One-Minute Chapter Summary

Revision paragraph

The cell is the basic structural and functional unit of life. Microscopes allow us to study structures beyond the resolution of the unaided eye. Every cell has a cell membrane, while plants, fungi and bacteria also possess a cell wall. Eukaryotic cells contain specialised organelles such as the nucleus, ER, Golgi apparatus, lysosomes and mitochondria; plant cells also contain plastids and a large vacuole. Water moves across selectively permeable membranes by osmosis. Cells multiply through division: mitosis supports growth and repair, while meiosis forms gametes and promotes diversity. Cell Theory states that living organisms are made of cells, cells are the basic units of life and new cells arise from pre-existing cells.

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