CLASS 9 • SCIENCE

CELL: THE BUILDING BLOCK OF LIFE

The Cell Interior — A Coordinated Working System

Concepts • labelled diagrams • comparisons • memory cues • practice

The big idea

A cell is an organised system. Different organelles perform different jobs, and their coordinated work keeps the cell alive.

1. The Cell Interior

Basic parts and specialised organelles

Most cells have three basic parts:

- **Plasma membrane:** a selectively permeable boundary controlling movement of substances into and out of the cell.
- **Cytoplasm:** a semi-fluid, jelly-like material in which many cell activities and organelles are present.
- **Nucleus:** the control centre containing genetic material in eukaryotic cells.

What are organelles?

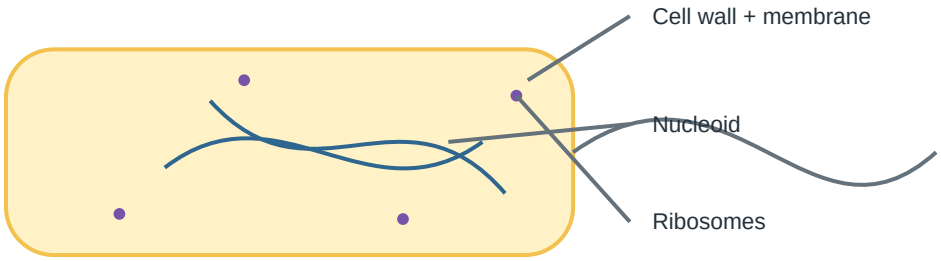
Organelles are specialised sub-cellular structures that perform particular functions inside a cell. Many are visible clearly only with an electron microscope.

Why are organelles useful?

- Different jobs can happen in different places.
- Chemical reactions can be organised efficiently.
- Materials can be made, stored and transported in a controlled way.
- Waste and damaged structures can be dealt with without disturbing the whole cell.

2. Three Cell Types

Bacterial, plant and animal cells



A bacterial cell is **prokaryotic**; plant and animal cells are **eukaryotic**.

Feature	Bacterial	Plant	Animal
Cell membrane	Present	Present	Present
Cell wall	Present	Present	Absent
Cytoplasm	Present	Present	Present
Well-defined nucleus	Absent	Present	Present
Primitive nucleus / nucleoid	Present	Absent	Absent
Membrane-bound organelles	Absent	Present	Present

Fast rule

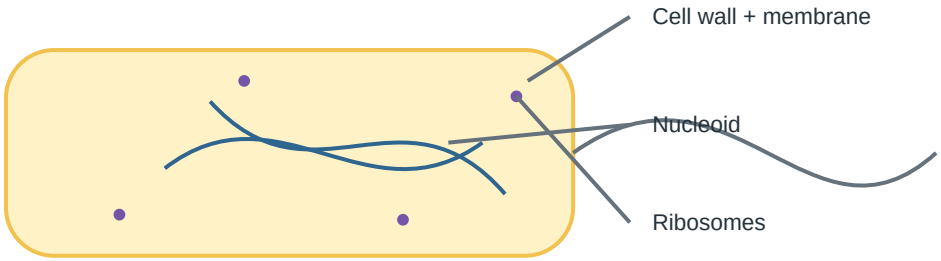
Prokaryotic = no membrane-bound nucleus.
Eukaryotic = well-defined, membrane-bound nucleus.

3. Prokaryotic vs Eukaryotic Cells

The key classification

Prokaryotic cells

A bacterial cell lacks a well-defined nucleus and membrane-bound organelles. Its DNA is usually a single circular molecule associated with specific proteins. The region containing this genetic material is the **nucleoid**.



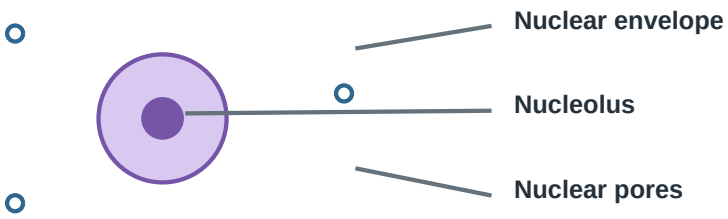
Eukaryotic cells

Plant and animal cells have a well-defined nucleus and several membrane-bound organelles. The term **eukaryotic** refers to cells with a true/well-defined nucleus.

Characteristic	Prokaryotic	Eukaryotic
Primitive nucleus	Present	Not present as a separate primitive nucleus
Typical diameter	About 1–10 µm	About 10–100 µm
Number of cells in organism	Usually unicellular	May be unicellular or multicellular
Membrane-bound organelles	Absent	Present
Membrane-bound nucleus	Absent	Present

4. Nucleus — House of Coded Instructions

Genetic control and inheritance



Structure and functions

- The nucleus has a **double-layered nuclear membrane (nuclear envelope)**.
- **Nuclear pores** allow movement of materials between the nucleus and cytoplasm.
- The nucleus contains nucleoplasm, chromatin and a **nucleolus**.
- The nucleolus is involved in the formation of ribosomal subunits.
- The nucleus stores genetic instructions and controls many cellular activities.

> **Remember**
>
> **Nucleus = instructions + control.** Think of it as the cell's library and command room.

Chromosomes, DNA and genes

- Chromosomes become clearly visible when a cell is about to divide.
- Chromosomes carry hereditary information in the form of DNA molecules.
- DNA = deoxyribonucleic acid.
- Genes are functional segments of DNA that contain genetic information.

5. DNA → Genes → Chromatin → Chromosomes

A visual memory chain

DNA
genetic molecule
→
Genes
functional DNA segments
→
Chromatin
DNA + proteins
→
Chromosomes
condensed during division

Special case: mature human RBCs

Mature red blood cells are **enucleated**. The absence of a nucleus leaves more room for haemoglobin and helps oxygen transport. They cannot repair or divide themselves and survive for about 120 days.

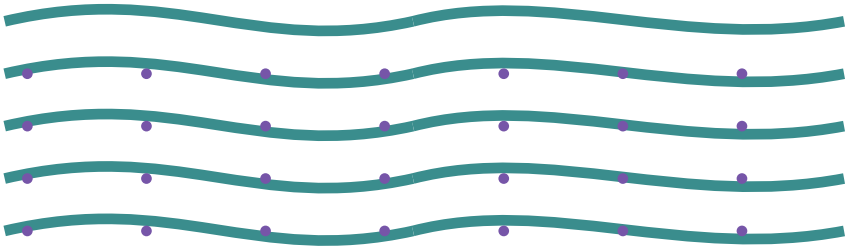
6. Ribosomes & Endoplasmic Reticulum

Making and moving cell materials

Ribosomes — protein factories

Ribosomes are tiny structures found freely in the cytoplasm or attached to the endoplasmic reticulum. They are the sites of **protein synthesis**.

Rough ER: ribosomes attached → proteins



Smooth ER: no ribosomes → lipids/fats + hormones

Endoplasmic reticulum (ER)

The ER is a large membrane network spread through the cytoplasm and continuous with the outer membrane of the nuclear envelope. It helps in the synthesis and transport of proteins, fats and, in specialised cells, some hormones.

Type	Key feature	Main role
Rough ER (RER)	Ribosomes attached	Protein synthesis and protein secretion
Smooth ER (SER)	No ribosomes	Synthesis of fats/lipids and hormones

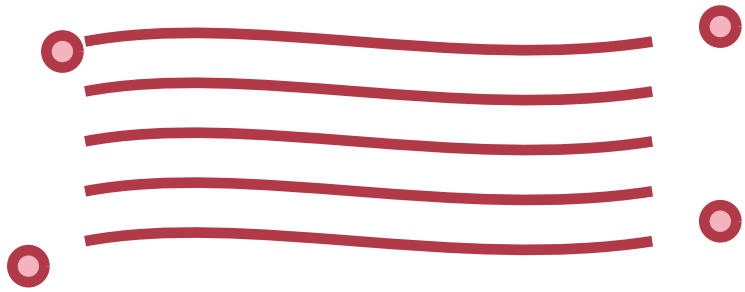
Memory cue

Rough = Ribosomes = proteins.
Smooth = no ribosomes = lipids/fats + hormones.

7. Golgi Apparatus

The packaging and shipping centre

Golgi apparatus



Modify • Sort • Package • Transport

The Golgi apparatus consists of stacks of flattened, sac-like structures. It is functionally linked to the ER, plasma membrane and other organelles.

- Modifies proteins and lipids.
- Sorts materials according to destination.
- Packages them into vesicles for transport or secretion.
- Participates in lysosome formation.

Easy analogy

Golgi apparatus = post office. It modifies, sorts, packages and sends materials to the correct destination.

8. Lysosomes

The clean-up and recycling system

Cells produce waste materials and damaged or worn-out structures during their activities. Lysosomes help prevent these wastes from accumulating.

Lysosome

A lysosome is a single membrane-bound sac filled with enzymes. These enzymes break down unwanted proteins, carbohydrates, fats and damaged cell parts. Digestion products may be reused in other cellular processes.

Interesting point

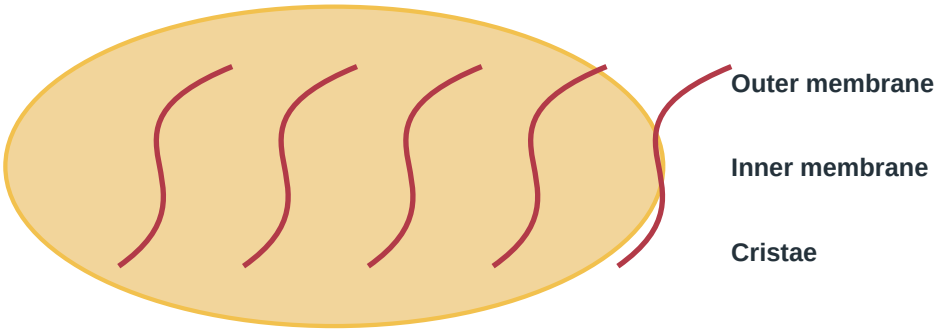
Human sperm cells contain lysosomal enzymes. When a sperm cell meets an egg, these enzymes help break down the outer layer of the egg, allowing fertilisation to take place.

Memory cue

Lysosome = clean + recycle.

9. Mitochondria — The Powerhouse

Energy for cellular activities



Mitochondria supply the energy needed for most cellular activities and are surrounded by two membranes.

- **Outer membrane:** smooth and porous.
- **Inner membrane:** folded inward into finger-like projections called **cristae**.
- Cristae increase surface area for chemical reactions and energy production.

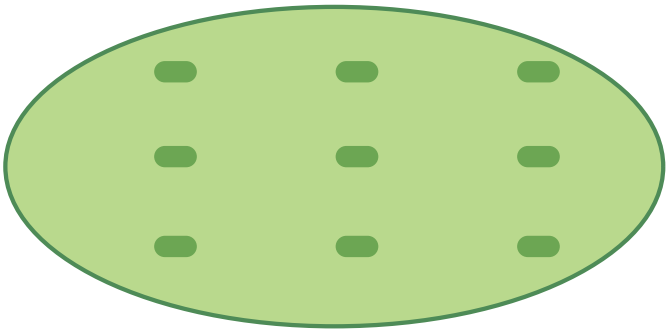
Special feature

Mitochondria contain their own DNA and ribosomes and can make some of their own proteins. These features suggest an evolutionary connection with ancient single-celled organisms.

10. Plastids

Food synthesis, storage and colour

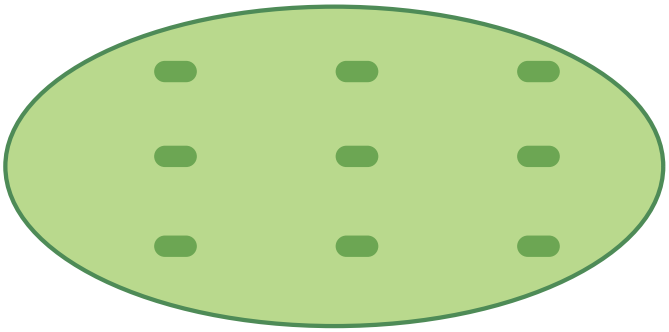
Plastids are specialised organelles found in plant cells. Different plastids perform different jobs.



Plastid	Main role	Key feature
Chloroplast	Photosynthesis / food synthesis	Chlorophyll; green
Chromoplast	Colour	Yellow, orange or red pigments
Leucoplast	Storage	Starch, oils or proteins

11. Chloroplast

The food-making organelle



Chloroplasts contain the green pigment **chlorophyll**, which absorbs sunlight for photosynthesis.

- Chloroplasts are double-membrane organelles.
- Inside is a semi-fluid substance called the **stroma**.
- Disc-shaped membrane structures containing chlorophyll capture light energy during photosynthesis.
- Sugars produced in photosynthesis can be stored as starch granules in the stroma.

Memory cue

Chloroplast → chlorophyll → sunlight → photosynthesis → food.

12. Chromoplasts & Leucoplasts

Colour and storage plastids

Chromoplasts — colour makers

In flower petals and fruits, plastids may contain pigments other than chlorophyll. These are called **chromoplasts**. Their pigments may be yellow, orange or red.

- Bright colours can attract pollinators to flowers.
- Bright fruit colours can attract animals that help in seed dispersal.

Leucoplasts — storage plastids

Some plastids lack pigments and are colourless. These are called **leucoplasts**.

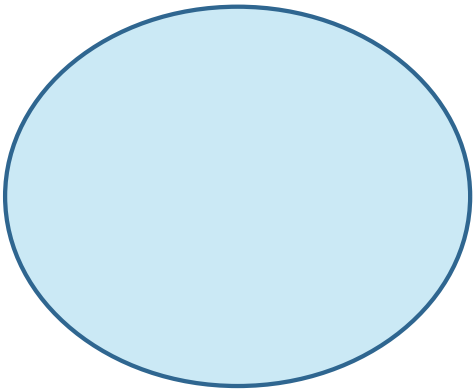
- Leucoplasts store starch, oils or proteins.
- The stored food depends on the type of tissue and plastid.
- For example, some leucoplasts in potato and taro store starch.

One-line memory

Chloro → chlorophyll → photosynthesis
Chromo → colour → bright pigments
Leuco → colourless → storage

13. Vacuoles

Storage, water balance and support



Tonoplast

Cell sap

Water + minerals

A mature plant cell usually contains one large central vacuole surrounded by a selectively permeable membrane called the **tonoplast**. The vacuole contains watery **cell sap**.

- Cell sap may contain water, minerals, sugars and waste materials.
- The vacuole stores large amounts of water and helps maintain pressure inside the cell.
- This pressure keeps a plant cell firm.
- When water is lacking, the vacuole loses water, cells become less firm and the plant becomes **wilted**.

Animal cells

Animal cells may contain small vacuoles. They are not usually as large as the central plant vacuole but can help in temporary storage of materials.

14. How Organelles Work Together

A coordinated working system

Nucleus
Instructions
→
Ribosomes / RER
Make proteins
→
Golgi
Modify + sort + package
→
Vesicles
Transport / secretion

Other major links

Mitochondria supply energy for cellular work. **Lysosomes** digest and recycle unwanted material. **Vacuoles** store substances and help with water balance. **Plastids** handle photosynthesis, colour or storage.

15. Organelle Quick-Revision Table

One glance before a test

Organelle	Think of it as…	Main function
Nucleus	Control room / library	Stores DNA; controls cell activities
Ribosome	Protein factory	Protein synthesis
Rough ER	Protein assembly line	Protein synthesis and transport
Smooth ER	Lipid factory	Lipid/fat and hormone synthesis
Golgi apparatus	Post office	Modifies, sorts, packages and ships
Lysosome	Cleaner / recycler	Digests waste and damaged parts
Mitochondria	Powerhouse	Energy production
Chloroplast	Solar kitchen	Photosynthesis
Chromoplast	Colour box	Bright pigments
Leucoplast	Store room	Food storage
Vacuole	Storage tank	Storage + water balance + support

16. High-Yield Differences

Frequently confused pairs

Pair	Difference to remember
Prokaryotic vs eukaryotic	Prokaryotic: no membrane-bound nucleus or membrane-bound organelles. Eukaryotic: well-defined nucleus and membrane-bound organelles.
RER vs SER	RER has ribosomes and mainly helps with proteins. SER has no ribosomes and helps with fats/lipids and hormones.
Chromoplast vs chloroplast	Chromoplasts give yellow/orange/red colours; chloroplasts contain chlorophyll and carry out photosynthesis.
Chloroplast vs mitochondria	Chloroplasts capture light energy to make food; mitochondria provide energy for cellular activities.
Plant vacuole vs animal vacuoles	Plant cells usually have one large central vacuole; animal cells may have smaller vacuoles.
Chromatin vs chromosome	Chromatin is less-condensed DNA-protein material; chromosomes are condensed, organised structures visible during cell division.

17. Threads of Curiosity

Science beyond the main organelles

J. Craig Venter and synthetic biology

In 2010, scientist **J. Craig Venter** and his team made an important discovery in synthetic biology. They first studied the complete DNA sequence of a simple bacterium called *Mycoplasma mycoides* using computer programming. They then chemically synthesised an exact copy of this DNA in the laboratory.

> **Why it matters**
>
> It showed how DNA information can be read, designed and chemically produced, contributing to synthetic biology.

Viruses, viroids and prions

These are infectious agents that are much simpler than cells.

- **Viruses:** genetic material surrounded by a protein coat.
- **Viroids:** small infectious RNA molecules without a protein coat.
- **Prions:** infectious abnormal proteins that lack genetic material.

18. Cytoskeleton & Cell Inclusions

Additional structures to remember

Cytoskeleton

In eukaryotic cells, the cytoskeleton is a network of fine fibres that provides structural support, maintains cell shape, and enables cell movement and internal transport.

Cell inclusions

The cytoplasm may contain stored substances that are not membrane-bound organelles. Examples include starch granules in plant cells and crystals of calcium oxalate or silica in some plant cells. These are called **cell inclusions**.

> **Remember**
>
> **Organelle = specialised structure with a job.**
> **Inclusion = stored material or deposit, not a membrane-bound organelle.**

19. Exam Practice

Short questions with answers

1. What are organelles?

Answer: Specialised sub-cellular structures that perform particular functions inside a cell.

2. What is the main difference between prokaryotic and eukaryotic cells?

Answer: Prokaryotic cells lack a membrane-bound, well-defined nucleus and membrane-bound organelles; eukaryotic cells have them.

3. What is a nucleoid?

Answer: The region of a prokaryotic cell containing its genetic material.

4. Why are ribosomes called protein factories?

Answer: Because they are the sites of protein synthesis.

5. Give two differences between RER and SER.

Answer: RER has ribosomes and mainly helps in protein synthesis/secretion; SER has no ribosomes and helps in lipid/fat and hormone synthesis.

6. Why is the Golgi apparatus compared with a post office?

Answer: It modifies, sorts and packages materials and sends them to their destinations.

7. What is the function of lysosomes?

Answer: They digest unwanted materials and damaged cell parts and help in recycling.

8. Why are mitochondria called the powerhouse?

Answer: They supply the energy needed for most cellular activities.

9. What are cristae?

Answer: Finger-like folds of the inner mitochondrial membrane that increase surface area for chemical reactions and energy production.

10. What is the role of chlorophyll?

Answer: It absorbs sunlight for photosynthesis.

11. What are chromoplasts?

Answer: Plastids containing pigments other than chlorophyll, often producing yellow, orange or red colours.

12. What are leucoplasts?

Answer: Colourless plastids that store food such as starch, oils or proteins.

13. What is cell sap?

Answer: The watery fluid stored inside a plant-cell vacuole.

14. How does a vacuole help a plant remain firm?

Answer: By storing water and maintaining internal pressure in the cell.

20. 60-Second Revision

Read once before a test

- **Plasma membrane** → selectively permeable boundary.
- **Cytoplasm** → jelly-like medium containing organelles.
- **Nucleus** → DNA + control.
- **Ribosome** → protein synthesis.
- **RER** → proteins.
- **SER** → fats/lipids + hormones.
- **Golgi** → modify + sort + package + ship.
- **Lysosome** → digest + recycle.
- **Mitochondria** → energy; inner folds = cristae.
- **Chloroplast** → chlorophyll + photosynthesis; fluid = stroma.
- **Chromoplast** → bright pigments/colour.
- **Leucoplast** → food storage.
- **Vacuole** → storage + water balance + support.
- **Prokaryotic** → no membrane-bound nucleus.
- **Eukaryotic** → well-defined nucleus + membrane-bound organelles.
- **DNA → genes → chromatin → chromosomes.**

Master memory chain

Nucleus → Ribosome/RER → Golgi → Vesicle
Instructions → Make → Process → Ship

Mitochondria → Energy Lysosome → Clean Vacuole → Store Chloroplast → Make food