Freebooks.pk

Free Notes • Past Papers • Guides for Students

Biology Class 9 — Punjab Board (PECTAA)

CHAPTER 3

The Cell

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

© freebooks.pk — Original educational content

Chapter 3: The Cell

Chapter 3 is about the cell, the smallest unit that can carry out all the activities of life. A useful way to picture a cell is as a small city: the nucleus acts as the government, mitochondria are power stations, the endoplasmic reticulum and Golgi apparatus are the roads and post office, and lysosomes are the waste-disposal service.

The chapter describes each part of the cell, from the cell wall and membrane to the nucleus, cytoskeleton and organelles, and compares plant and animal cells. It then explains how cells become specialised for particular jobs (mesophyll, epidermal, muscle, nerve, red blood and liver cells), how division of labour works inside and between cells, and what makes stem cells special.

Learning Objectives

- Describe the cell as the basic structural and functional unit of life.
- Give the structure and function of the cell wall, cell membrane, cytoplasm, nucleus and cytoskeleton.
- Describe ribosomes, endoplasmic reticulum, Golgi apparatus, lysosomes, mitochondria, plastids, vacuoles, centrioles, cilia and flagella.
- Compare plant and animal cells and state the advantages of each design.
- Explain cell specialisation with examples from plants and animals.
- Explain division of labour within a cell and across cells.
- Define stem cells and give examples of their role in the body.

Key Concepts

3.1 The Cell and Its Discovery

All organisms, from bacteria to whales, are made of cells, so the cell is called the basic unit of life. Most cells are microscopic, but a few can be seen with the naked eye, such as an ostrich egg cell, the single-celled alga Acetabularia and the giant amoeba.

Robert Hooke first described cells in 1665 when he looked at a thin slice of cork through his microscope and saw tiny box-like spaces. Better microscopes in the nineteenth century revealed internal details; in 1831 Robert Brown identified the nucleus. Cells are of two basic types: prokaryotic cells have no membrane-bound organelles, while eukaryotic cells have a nucleus and many membrane-bound organelles.

3.2 Cell Wall and Cell Membrane

A cell wall is a rigid, non-living layer outside the membrane in bacteria, fungi, plants and algae. It gives shape, strength and protection. A plant cell wall has three layers: the middle lamella (pectin with calcium and magnesium) cements neighbouring cells together; the primary wall (cellulose fibres with hemicellulose and pectin) lies next to the membrane; and some cells such as xylem add a secondary wall of cellulose and lignin on the inner side. Channels called plasmodesmata pass

Free notes: freebooks.pk

through walls and connect neighbouring plant cells. Bacterial walls are made of peptidoglycan and fungal walls of chitin.

Every cell has a thin, flexible cell membrane that is selectively permeable: it lets some substances through and keeps others out. It is made of lipids and proteins with a little carbohydrate. The fluid mosaic model describes it as a double layer of lipids in which proteins float; both can move sideways, so the pattern keeps changing. Carbohydrates attach to proteins (glycoproteins) or lipids (glycolipids), and animal cell membranes also contain cholesterol.

3.2 Cytoplasm, Nucleus and Cytoskeleton

Cytoplasm is the jelly-like material between the membrane and the nucleus, made of water, proteins, enzymes and salts. It holds the organelles, allows materials to move, stores food and wastes, and is the site of reactions such as glycolysis. Its fluid part, without the membrane-bound organelles, is called cytosol.

The nucleus is the control centre of a eukaryotic cell. It is surrounded by a double nuclear envelope with nuclear pores. Inside is the nucleoplasm containing one or more nucleoli, where ribosome parts are made, and chromatin made of DNA and proteins. When the cell divides, chromatin coils into chromosomes. DNA carries genes that control the cell and pass characteristics to the next generation. Prokaryotes have no true nucleus; their DNA lies free in the cytoplasm.

The cytoskeleton is a network of protein fibres. Microtubules (tubulin) keep the cell's shape, guide organelle movement and form the spindle, cilia and flagella. Microfilaments (actin) allow movement such as muscle contraction and white blood cell crawling. Intermediate filaments (keratin, vimentin) anchor the nucleus and form cell junctions.

3.2 Organelles for Making and Processing Materials

Ribosomes are tiny granules of protein and ribosomal RNA where proteins are made. They have two subunits that join during protein synthesis, have no membrane, and are found free in the cytoplasm, on rough ER and in prokaryotes too (eukaryotic ribosomes are slightly larger).

The endoplasmic reticulum is a network of membrane channels. Rough ER carries ribosomes and makes proteins; smooth ER has no ribosomes and makes lipids, transports materials, breaks down toxic chemicals and helps muscle contraction. The Golgi apparatus, described by Camillo Golgi in 1898, is a stack of flat sacs (cisternae) that modifies proteins from rough ER and packs them into Golgi vesicles for storage or secretion.

Lysosomes, discovered by Christian de Duve, are small vesicles budded from the Golgi apparatus and filled with digestive enzymes. They fuse with food vacuoles to digest food, break down worn-out organelles and cell waste, and are mainly found in animal cells.

3.2 Energy Organelles: Mitochondria and Plastids

Mitochondria are the powerhouses of the cell, where aerobic respiration breaks down glucose using oxygen to release energy as ATP. Each has a smooth outer membrane and a folded inner membrane; the folds (cristae) increase the surface for respiration and enclose a fluid matrix. Mitochondria have their own DNA and ribosomes similar to those of prokaryotes.

Plastids occur in plants and algae. Chloroplasts are green and carry out photosynthesis; they have

a double membrane, stacks (grana) of disc-like thylakoids carrying chlorophyll, a fluid stroma, and their own DNA and ribosomes. Chromoplasts contain bright pigments such as carotenoids that colour petals and fruits, attracting pollinators and seed dispersers. Leucoplasts are colourless and store starch, oils and proteins in roots, seeds and underground stems.

3.2 Vacuoles, Centrioles, Cilia and Flagella

Vacuoles are fluid-filled sacs bounded by one membrane. Animal cells have several small temporary vacuoles; freshwater protists such as Amoeba use contractile vacuoles to pump out extra water; food vacuoles digest and store food. A mature plant cell usually has one large central vacuole, bounded by the tonoplast and filled with cell sap. It pushes the nucleus to one side and presses the cytoplasm against the wall, producing turgor pressure that keeps the cell firm.

Centrioles are barrel-shaped structures made of nine triplets of microtubules, found in pairs at right angles (a centrosome) in animal cells and most protists but not in higher plants, fungi or prokaryotes. They form spindle fibres that separate chromosomes during cell division; centrioles at the base of cilia and flagella are called basal bodies. Cilia are short and numerous while flagella are long and few; in eukaryotes both have a 9 + 2 arrangement of microtubules and are used for movement. Prokaryotic flagella are built differently, from the protein flagellin.

3.3 Plant and Animal Cells Compared

Both plant and animal cells have a membrane, cytoplasm, nucleus, mitochondria, ribosomes, ER and Golgi apparatus. Only plant cells have a cellulose cell wall, chloroplasts and a large central vacuole; animal cells have centrioles and lysosomes and lack a wall. The nucleus is central in animal cells but pushed to the side in mature plant cells.

The plant design gives support (wall), food-making (chloroplasts), storage and turgor (vacuole) and cell-to-cell links (plasmodesmata). The animal design allows accurate chromosome separation (centrioles), efficient clean-up (lysosomes), movement by cilia or flagella, and flexibility of shape because there is no rigid wall, which lets white blood cells squeeze to infection sites.

3.4 Cell Specialisation and Division of Labour

New cells made by division are similar at first; they then specialise (differentiate), developing the size, shape and contents needed for one job. Mesophyll cells in leaves are packed with chloroplasts for photosynthesis. Epidermal cells are flat and tightly fitted to protect plant organs; some become root hair cells for absorption or guard cells that open and close stomata.

Muscle cells are long and full of contractile proteins: skeletal muscle is striated and voluntary, cardiac muscle is branched, striated and involuntary, and smooth muscle is spindle-shaped, unstriated and involuntary. Neurons have a cell body, short dendrites that bring impulses in and a long axon that carries them away. Red blood cells are biconcave discs packed with haemoglobin; mammalian red cells lose their nucleus and organelles to hold more haemoglobin. Liver cells (hepatocytes) store glycogen, iron and vitamins, detoxify chemicals, make clotting proteins, recycle old red cells, turn ammonia into urea and secrete bile; they have large nuclei, many mitochondria, much smooth ER and many peroxisomes.

Division of labour means different parts doing different jobs so the whole works efficiently. Inside a

cell, organelles share the work (mitochondria release energy, ER makes proteins and lipids, lysosomes digest waste). In a multicellular body, different cell types share the work (muscle cells move, nerve cells carry messages, red blood cells carry oxygen).

3.5 Stem Cells

A stem cell is an unspecialised cell that can divide and give rise to different types of specialised cells. The zygote is the first stem cell: its descendants form separate cell lines that become skin, muscle, nerve and blood cells.

Adult stem cells remain in many tissues throughout life and replace or repair cells as needed. Skin stem cells help heal wounds, liver stem cells help the liver recover from damage, and bone marrow stem cells keep producing red blood cells, white blood cells and platelets. The gut lining and bone marrow depend on them constantly.

Important Definitions

Cell
The smallest structural and functional unit of life.

Prokaryotic cell
A cell without a nucleus or membrane-bound organelles, such as a bacterial cell.

Eukaryotic cell
A cell with a membrane-bound nucleus and membrane-bound organelles.

Middle lamella
The pectin-rich layer that cements the walls of neighbouring plant cells together.

Plasmodesmata
Channels through plant cell walls that connect the cytoplasm of neighbouring cells.

Selectively permeable
Allowing some substances to pass through while stopping others.

Fluid mosaic model
The model of the cell membrane as a moving double layer of lipids with proteins floating in it.

Cytosol
The fluid part of the cytoplasm, excluding membrane-bound organelles.

Chromatin
Thread-like material in the nucleus made of DNA and proteins, which condenses into chromosomes during division.

Nucleolus

A dense body inside the nucleus where ribosome parts are assembled.

Cytoskeleton
A network of microtubules, microfilaments and intermediate filaments that supports the cell and helps it move.

Ribosome
A small particle of RNA and protein where proteins are made.

Cisternae
The flattened sacs that are stacked to form the Golgi apparatus.

Lysosome
A membrane vesicle containing digestive enzymes.

Cristae
Folds of the inner mitochondrial membrane that increase the surface area for respiration.

Thylakoid
A flattened membrane sac in a chloroplast that carries chlorophyll; stacks of thylakoids form grana.

Tonoplast
The membrane surrounding the central vacuole of a plant cell.

Turgor pressure
The outward pressure of the vacuole's contents on the cytoplasm and cell wall, which keeps a plant cell firm.

Centrosome
A pair of centrioles lying at right angles near the nucleus of an animal cell.

Cell specialisation
The process by which a cell develops a particular structure to perform a particular function.

Division of labour
Sharing of different tasks among different parts of a system so that it works efficiently.

Stem cell
An unspecialised cell that can divide and form different kinds of specialised cells.

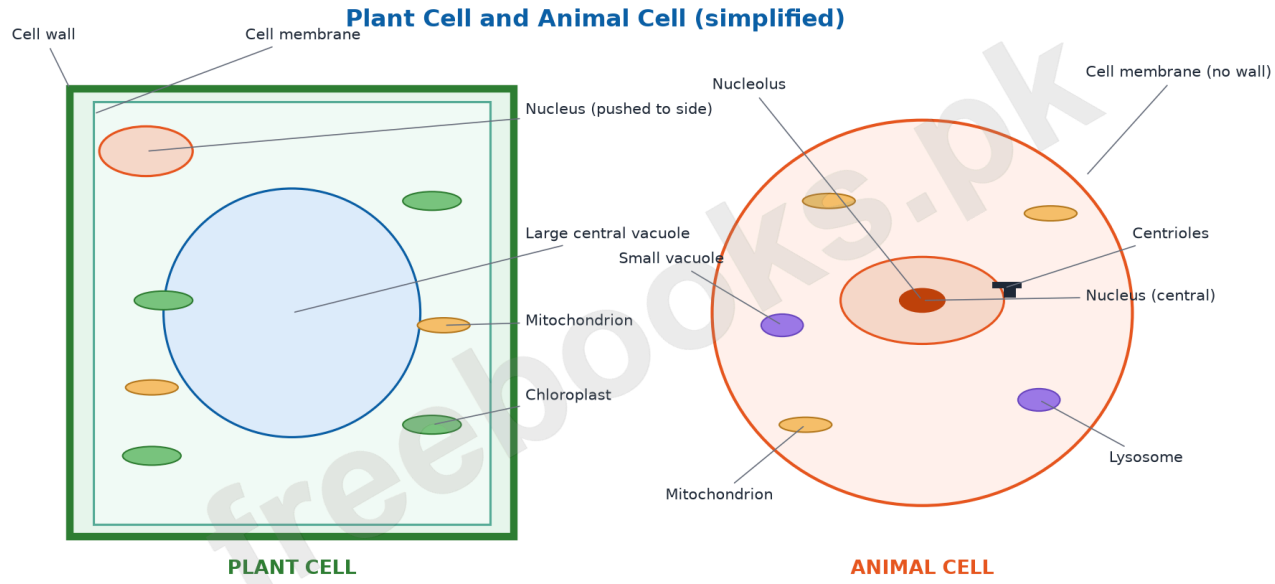
Key Facts at a Glance

Organelle	Main job

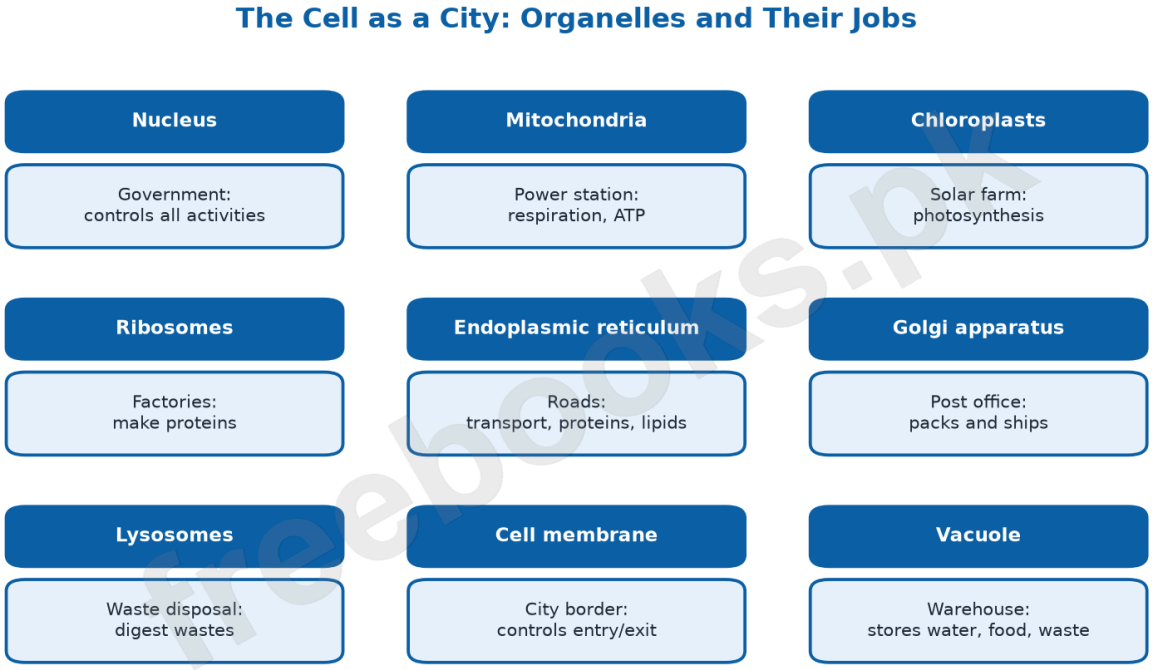
Cell wall	Shape, support, protection (plants, fungi, bacteria, algae)
Cell membrane	Controls entry and exit of substances
Nucleus	Controls cell activities; contains DNA
Nucleolus	Assembles ribosome parts
Ribosome	Protein synthesis
Rough ER	Makes proteins
Smooth ER	Makes lipids, detoxifies, transports
Golgi apparatus	Modifies and packs proteins for secretion
Lysosome	Digests food, waste and old organelles
Mitochondrion	Aerobic respiration, releases ATP
Chloroplast	Photosynthesis
Chromoplast / Leucoplast	Colour / food storage
Central vacuole	Stores cell sap, gives turgor
Centrioles	Form spindle fibres; basal bodies of cilia
Cilia and flagella	Movement (9 + 2 microtubules)

Diagrams

Plant cell and animal cell: Simplified labelled sketches of a plant cell and an animal cell side by side, showing the parts they share and the parts found in only one of them.

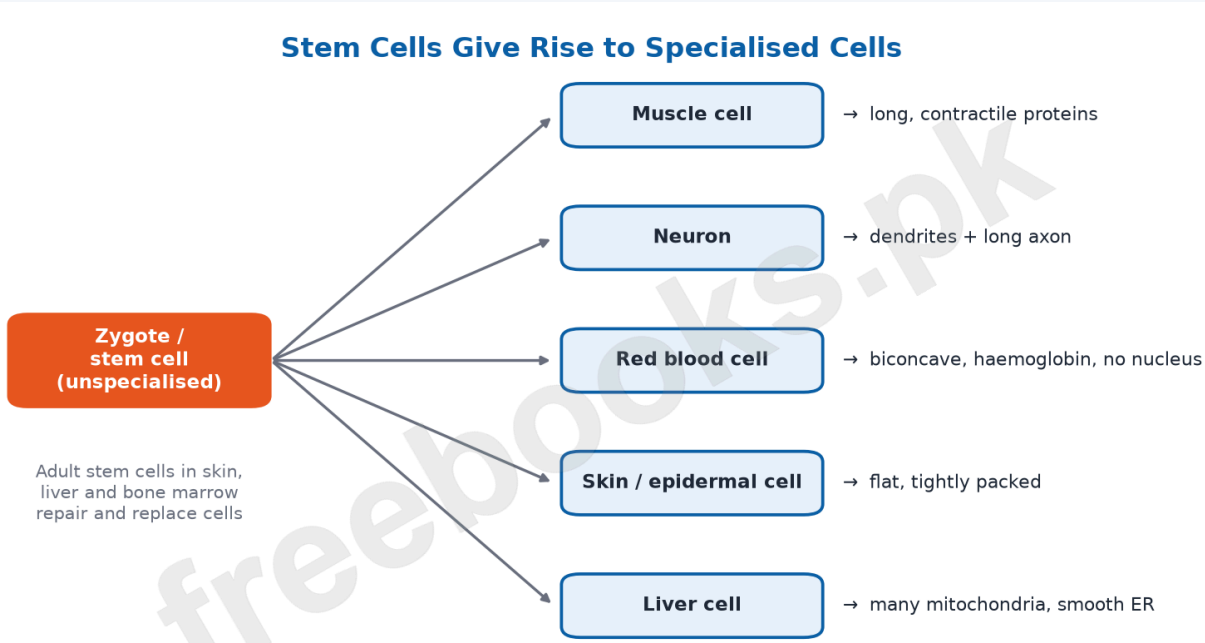


Cell organelles and their jobs: The city model of the cell: each organelle matched with its role, from the nucleus as control centre to lysosomes as waste disposal.



Stem cells and specialised cells: A zygote and adult stem cells giving rise to specialised cells such as muscle cells, neurons, red blood cells and skin cells, each with its key adaptation.

freebooks.pk



freebooks.pk

Short Questions and Answers

Why is the cell called the basic unit of life?

Because every living thing is made of cells, and the cell is the smallest unit that can carry out all life processes such as nutrition, respiration and reproduction.

What did Robert Hooke and Robert Brown discover?

Hooke described cells in 1665 by observing box-like spaces in a cork slice; Brown identified the nucleus in plant cells in 1831.

How is the secondary wall different from the primary wall?

The primary wall is thin, flexible and made mainly of cellulose, hemicellulose and pectin; the secondary wall forms later inside it in some cells such as xylem and is thicker and stronger because it also contains lignin.

Why is the cell membrane called fluid mosaic?

Its lipids form a fluid double layer in which proteins are scattered like the pieces of a mosaic, and both can move sideways, so the pattern keeps changing.

What is the difference between chromatin and chromosomes?

Chromatin is the loose thread-like form of DNA and protein in a non-dividing nucleus; chromosomes are the thick, condensed form that chromatin takes when the cell divides.

Why are mitochondria called the powerhouses of the cell?

They carry out aerobic respiration, breaking down glucose with oxygen to release energy in the form of ATP, which the cell uses for its work.

How does rough ER differ from smooth ER?

Rough ER has ribosomes on its surface and makes proteins; smooth ER has no ribosomes and makes lipids, detoxifies harmful chemicals and transports materials.

How do the Golgi apparatus and lysosomes work together?

The Golgi apparatus packages digestive enzymes into vesicles that bud off as lysosomes; these lysosomes then fuse with food vacuoles or worn-out organelles and digest them.

Why do cells in fruits and flower petals have chromoplasts?

Chromoplasts contain bright pigments that colour petals and fruits, attracting insects for pollination and animals that disperse seeds.

Why are vacuoles called the storage and waste bins of the cell?

They hold water, food, salts and waste products, keeping these substances away from the rest of the cytoplasm until they are used or removed.

How does the central vacuole keep a plant cell firm?

It fills with cell sap and presses the cytoplasm against the cell wall; this turgor pressure keeps the cell stiff and helps the plant stay upright.

Why can white blood cells change shape but plant cells cannot?

Animal cells have no rigid cell wall and use their cytoskeleton to move, so white blood cells can squeeze through gaps; plant cells are held in shape by a rigid cellulose wall.

How is a red blood cell adapted to carry oxygen?

Its biconcave disc shape gives a large surface for gas exchange, and in mammals it loses its nucleus and organelles so that it can be packed with more haemoglobin.

Why do liver cells contain many mitochondria and much smooth ER?

Liver cells do energy-hungry work such as making proteins and detoxifying chemicals; mitochondria supply the ATP and smooth ER carries out detoxification and lipid synthesis.

What is a stem cell? Give one example.

A stem cell is an unspecialised cell that can divide and form different specialised cells. Bone marrow stem cells, for example, keep producing new red and white blood cells.

Long Questions and Answers

Describe the structure and functions of the cell wall and the cell membrane.

Which cells have a cell wall and what does it do?

Bacteria, fungi, plants and algae have a rigid non-living cell wall outside the membrane. It gives the cell shape, mechanical strength and protection and prevents it from bursting.

What are the layers of a plant cell wall?

The middle lamella, made of pectin with calcium and magnesium, joins neighbouring cells. The primary wall, made of crossing cellulose fibres with hemicellulose and pectin, lies against the membrane. Some cells such as xylem add a secondary wall of cellulose and lignin inside the primary wall.

What is the cell membrane made of?

It is made of a double layer of lipids with proteins embedded in it, plus small amounts of carbohydrates attached as glycoproteins and glycolipids. Animal cell membranes also contain cholesterol.

What does the fluid mosaic model explain?

It explains that the lipids form a fluid layer in which proteins move about, so the membrane is flexible and its pattern constantly changes. The membrane is selectively permeable and controls what enters and leaves the cell.

Describe the structure and function of the nucleus.

What surrounds the nucleus?

A double membrane called the nuclear envelope surrounds the nucleus. It has many nuclear pores that allow materials such as RNA to pass between the nucleus and cytoplasm.

What is inside the nucleus?

The nucleoplasm contains one or more nucleoli, where ribosome parts are assembled, and chromatin made of DNA and proteins. During division, chromatin condenses into chromosomes.

Why is the nucleus called the control centre?

Its DNA contains genes that direct the making of proteins, and proteins carry out and control nearly all cell activities. DNA also passes characteristics to the next generation, so it is the hereditary material.

Describe the structure and functions of mitochondria and chloroplasts.

What is the structure of a mitochondrion?

A mitochondrion has a smooth outer membrane and a folded inner membrane. The folds, called cristae, enclose a fluid matrix and give a large surface for the reactions of respiration.

What do mitochondria do?

They carry out aerobic respiration, using oxygen to break down glucose and release energy stored as ATP, which powers activities such as movement and synthesis.

What is the structure of a chloroplast?

A chloroplast has a double membrane enclosing a fluid stroma. Inside are stacks called grana, each made of disc-shaped thylakoids that carry chlorophyll.

What features do mitochondria and chloroplasts share?

Both have double membranes, contain their own DNA and ribosomes, and deal with energy: chloroplasts capture light energy to make glucose, and mitochondria release the energy stored in glucose.

Compare plant and animal cells and explain the advantages of each.

What parts do plant and animal cells share?

Both have a cell membrane, cytoplasm, nucleus, mitochondria, ribosomes, endoplasmic reticulum and Golgi apparatus, because these carry out basic life processes in all eukaryotic cells.

What parts are found only in plant cells?

Plant cells have a cellulose cell wall for support, chloroplasts for photosynthesis, a large central vacuole for storage and turgor, and plasmodesmata that connect neighbouring cells.

What parts are typical of animal cells?

Animal cells have centrioles that form spindle fibres, lysosomes for digestion and clean-up, and in some cells cilia or flagella for movement. They have no cell wall.

Why is each design useful?

The plant cell is built for support and making food, which suits a plant that stays in one place. The animal cell is flexible and can change shape and move, which suits animals that must search for food and respond quickly.

What is cell specialisation? Explain with examples and describe division of labour.

What does cell specialisation mean?

After cell division, new cells are alike, but they then develop special shapes and contents to perform one particular task. This process is called specialisation or differentiation.

How are plant cells specialised?

Mesophyll cells contain many chloroplasts for photosynthesis. Epidermal cells are flat and tightly packed for protection; root hair cells grow long extensions to absorb water and guard cells control the stomata.

How are animal cells specialised?

Muscle cells are long and contractile, neurons have dendrites and a long axon to carry impulses, red blood cells are biconcave and full of haemoglobin, and liver cells have many mitochondria and much smooth ER for detoxification and synthesis.

What is division of labour within and across cells?

Within a cell, organelles divide the work: mitochondria release energy, ER makes proteins and lipids and lysosomes digest waste. Across cells, different cell types share the work of the body, which lets complex organisms perform many functions efficiently.

Multiple Choice Questions (MCQs)

The first scientist to describe cells, using a slice of cork, was: (A) Robert Brown (B) Robert Hooke (C) Camillo Golgi (D) Christian de Duve
Correct answer: (B) Robert Hooke. Hooke described cork cells in 1665.

The layer that cements two neighbouring plant cells together is the: (A) Primary wall (B) Secondary wall (C) Middle lamella (D) Cell membrane
Correct answer: (C) Middle lamella. The middle lamella is rich in pectin and joins adjacent walls.

Lignin is mainly found in the: (A) Middle lamella (B) Primary wall (C) Secondary wall (D) Cell membrane
Correct answer: (C) Secondary wall. The secondary wall contains cellulose and lignin.

Which structure is selectively permeable? (A) Cell wall (B) Cell membrane (C) Middle lamella (D) Cell sap
Correct answer: (B) Cell membrane. The membrane controls what enters and leaves the cell.

Ribosome subunits are assembled in the: (A) Nucleolus (B) Golgi apparatus (C) Lysosome (D) Vacuole
Correct answer: (A) Nucleolus. The nucleolus is where ribosome parts are made.

A cell that makes large amounts of digestive enzymes for export would have plenty of: (A) Rough ER and Golgi apparatus (B) Chloroplasts (C) Centrioles only (D) Leucoplasts
Correct answer: (A) Rough ER and Golgi apparatus. Rough ER makes the proteins and the Golgi packs them for secretion.

Which organelle detoxifies harmful chemicals in liver cells? (A) Rough ER (B) Smooth ER (C) Ribosome (D) Centriole
Correct answer: (B) Smooth ER. Smooth ER carries out detoxification.

The folds of the inner mitochondrial membrane are called: (A) Grana (B) Cristae (C) Cisternae (D) Thylakoids
Correct answer: (B) Cristae. Cristae increase the surface area for respiration.

Colourless plastids that store starch are: (A) Chloroplasts (B) Chromoplasts (C) Leucoplasts (D) Lysosomes
Correct answer: (C) Leucoplasts. Leucoplasts have no pigment and store food.

Which organelle is found in animal cells but not in higher plant cells? (A) Mitochondrion (B) Centriole (C) Ribosome (D) Golgi apparatus
Correct answer: (B) Centriole. Higher plants lack centrioles.

The membrane around the central vacuole of a plant cell is the: (A) Tonoplast (B) Nuclear envelope (C) Plasmodesma (D) Middle lamella
Correct answer: (A) Tonoplast. The tonoplast surrounds the vacuole.

Microtubules in eukaryotic cilia and flagella are arranged as: (A) 9 + 0 (B) 9 + 2 (C) 9 triplets only (D) 2 + 2
Correct answer: (B) 9 + 2. Nine outer pairs surround one central pair.

Which cell type has dendrites and an axon? (A) Muscle cell (B) Neuron (C) Mesophyll cell (D) Red blood cell
Correct answer: (B) Neuron. Neurons receive impulses through dendrites and send them along the axon.

Mature mammalian red blood cells lack a nucleus so that they can: (A) Divide faster (B) Hold more haemoglobin (C) Make more ATP (D) Move by flagella
Correct answer: (B) Hold more haemoglobin. Extra space is used for haemoglobin.

Cells in bone marrow that keep forming new blood cells are: (A) Guard cells (B) Stem cells (C) Mesophyll cells (D) Epidermal cells
Correct answer: (B) Stem cells. Bone marrow stem cells produce blood cells throughout life.

Quick Revision Summary

- Cell = basic unit of life. Hooke saw cells in cork (1665); Brown found the nucleus (1831).
- Plant wall: middle lamella (pectin) + primary wall (cellulose) + secondary wall (cellulose + lignin); plasmodesmata link cells.
- Membrane: lipid bilayer with proteins (fluid mosaic), selectively permeable.
- Nucleus: envelope with pores, nucleolus (ribosome parts), chromatin (DNA + protein) → chromosomes in division.
- Ribosome = protein synthesis; RER = proteins; SER = lipids and detox; Golgi = packaging; lysosome = digestion.
- Mitochondria = respiration (cristae, matrix); chloroplasts = photosynthesis (grana, thylakoids, stroma); both have DNA.
- Plant only: wall, chloroplasts, large vacuole. Animal only: centrioles, lysosomes (mainly), no wall.
- Specialised cells: mesophyll, epidermal, muscle, neuron, red blood cell, liver cell. Stem cells are unspecialised and can form many cell types.

Exam Tips

- Learn each organelle with three words: what it looks like, where it is found, what it does.
- Practise drawing and labelling a plant cell and an animal cell; diagram questions are common and the labels carry marks.
- Keep look-alike terms apart: cristae (mitochondria) vs grana (chloroplast) vs cisternae (Golgi).
- For specialised cell questions, always link a structural feature to the job it helps with.
- When comparing plant and animal cells, use a two-column table; it is quicker to write and easier to mark.

Note on Facts

The textbook places cholesterol on the inner side of the membrane. In fact cholesterol molecules sit within both layers of the lipid bilayer of animal cell membranes, where they help control membrane fluidity.