BN02 — Cell Biology (Cytology)

📖 Chapter BN02 · NDA Class 11–12 Level 🎯 NDA Level : High Priority

Cell Biology is the engine room of Biology in NDA. Questions consistently appear on cell organelle functions, prokaryote vs eukaryote differences, types of tissues, and stages of cell division. The organelle "powerhouse" and "suicide bag" nicknames, mitosis vs meiosis differences, and the cell cycle phases are directly tested — often with statement-based or match-the-column formats. Master the function of each organelle and the visible changes in each division stage.

📌 **What to expect in NDA (based on 2022–2025 pattern):**
(1) Prokaryotic vs eukaryotic cells — key structural differences;
(2) Cell organelle functions (especially mitochondria, chloroplast, ribosome, lysosome, nucleus);
(3) Plant vs animal cell differences (cell wall, chloroplast, vacuole, centriole);
(4) Animal and plant tissue types — names, subtypes, locations, and functions;
(5) Mitosis stages (PMAT) and their visible events; significance;
(6) Meiosis vs Mitosis key differences; significance of meiosis in sexual reproduction.

Topics at a Glance

① Cell Structure
Prokaryote vs Eukaryote; Plant vs Animal cell

② Cell Organelles
Structure & function of 9 key organelles

③ Tissues
Plant (meristematic/permanent) & Animal tissues

④ Cell Division
Cell cycle, Mitosis, Meiosis & comparison

1. Cell Structure: Prokaryotic vs Eukaryotic

Prokaryotic vs Eukaryotic Cells

1.1

The single most-tested structural concept in NDA Cell Biology — know every row of this comparison

Feature	Prokaryotic Cell	Eukaryotic Cell
Nuclear membrane	Absent (naked DNA)	Present (true nucleus)
Size	Small (1–10 µm)	Larger (10–100 µm)
Chromosome	Single circular DNA	Multiple linear chromosomes
Membrane-bound organelles	Absent (no mitochondria, ER etc.)	Present
Ribosomes	70S (smaller)	80S (larger); 70S in mitochondria/chloroplast
Cell wall	Present (peptidoglycan in bacteria)	Present in plants (cellulose); absent in animals
Plasmid	Often present	Absent
Examples	Bacteria, Cyanobacteria (Blue-green algae)	All animals, plants, fungi, protists

📌 **NDA Trap:** Mitochondria and Chloroplasts contain **70S ribosomes** (same as prokaryotes) — this is evidence for the endosymbiotic theory (these organelles were once free-living bacteria). This is a favourite NDA statement-match trap.

1.2

Plant Cell vs Animal Cell

Differences directly tested — NDA often asks "which structure is absent in animal cells?"

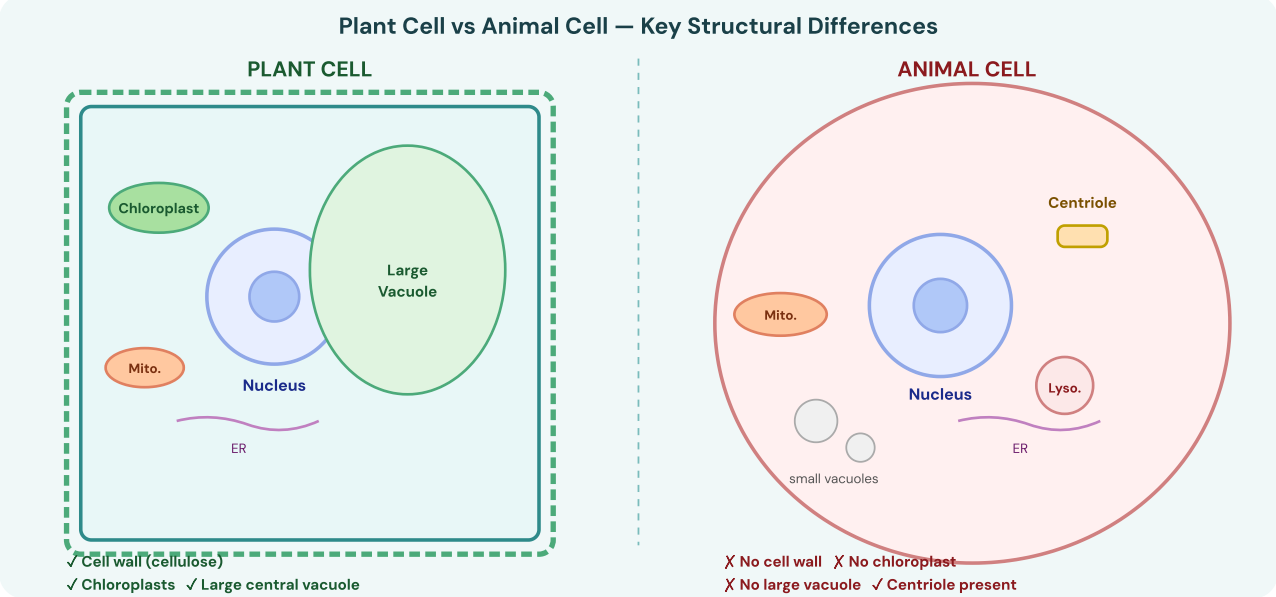

Fig. 1 — Plant cell (left) vs Animal cell (right). Green ticks mark features unique to plant cells; red crosses mark features absent in animal cells. Centrioles are present only in animal cells.

🌿 Present in Plant Cell ONLY

- **Cell wall** — made of cellulose; gives rigidity
- **Chloroplasts** — site of photosynthesis; contain chlorophyll
- **Large central vacuole** — maintains turgor pressure; stores water/salts
- **Plasmodesmata** — cytoplasmic bridges between plant cells

🦏 Present in Animal Cell ONLY

- **Centrioles** — form spindle fibres during cell division; absent in most plant cells
- **Lysosomes** — more prominent; plant cells have vacuoles for digestion
- **Irregular shape** — no rigid wall, flexible membrane

PYQ

Topic-Wise PYQs — Cell Structure

Q1. Which of the following is present in a prokaryotic cell but absent in a eukaryotic cell?

A. Ribosome

B. Cell membrane

C. Plasmid

D. DNA

Answer: C — Plasmid. Plasmids are small, circular, extrachromosomal DNA molecules found in bacteria (prokaryotes). Ribosomes, cell membranes, and DNA are present in both. This is a high-frequency NDA question — remember: plasmid = prokaryote exclusive.

Q2. Which structure is found in animal cells but NOT in plant cells?

A. Mitochondria

B. Endoplasmic reticulum

C. Centriole

D. Golgi apparatus

Answer: C — Centriole. Centrioles are present in animal cells and are essential for forming the spindle apparatus during cell division. Plant cells (except lower plants)

lack centrioles but still divide using a different spindle formation mechanism.

Q3. The cell wall of bacteria is chemically composed of:

A. Cellulose

B. Chitin

C. Peptidoglycan (Murein)

D. Lignin

Answer: C — Peptidoglycan (Murein). Bacterial cell walls are made of peptidoglycan — a polymer of sugars and amino acids. Plant cells use cellulose, fungi use chitin, and lignin provides secondary wall reinforcement in woody plants. This distinction is tested frequently in NDA.

2. Cell Organelles — Structure & Functions

2.1 Key Organelles — Functions at a Glance

Nickname + one key function per organelle is the NDA minimum — aim to know all bullet points

Cell Membrane

"Gatekeeper of the cell"

- Selectively permeable phospholipid bilayer
- Controls entry/exit of substances (osmosis, diffusion, active transport)
- Fluid mosaic model (Singer & Nicolson, 1972)
- Made of phospholipids + proteins (cholesterol in animals)

Nucleus

"Control centre / Brain of the cell"

- Surrounded by double membrane (nuclear envelope) with pores
- Contains DNA → controls heredity and cell activities
- Nucleolus inside nucleus → site of rRNA synthesis
- Absent in RBCs of mammals; absent in prokaryotes

Mitochondria

"Powerhouse of the cell"

- Site of cellular respiration (ATP production)
- Double membrane: outer smooth + inner folded (cristae)
- Has own 70S ribosomes and circular DNA
- Most in liver cells, heart muscle (high energy demand)
- ATP = Adenosine Triphosphate = energy currency

Chloroplast

"Kitchen of the cell"

- Site of photosynthesis; found ONLY in plant cells
- Double membrane; internal thylakoid membranes (grana)
- Contains chlorophyll (green pigment) in thylakoids
- Has own 70S ribosomes and DNA (like mitochondria)
- Stroma = fluid around grana (dark reactions occur here)

Endoplasmic Reticulum (ER)

"Transport highway / Internal skeleton"

- **Rough ER (RER):** has ribosomes; synthesises and transports proteins
- **Smooth ER (SER):** no ribosomes; lipid/steroid synthesis, detoxification
- Connected to nuclear envelope and cell membrane
- First discovered by Porter (1945)

Golgi Apparatus

"Post office / Traffic police of the cell"

- Receives proteins from RER, modifies, packages, and ships them
- Forms lysosomes and secretory vesicles
- Stack of flattened membrane sacs (cisternae)
- Discovered by Camillo Golgi (1898)
- Also called Golgi body or Golgi complex

Lysosomes

"Suicide bag / Janitor of the cell"

- Contains hydrolytic (digestive) enzymes
- Digests worn-out organelles (autophagy) and foreign particles
- Bursts during cell injury → digests the cell itself (autolysis)
- Formed by Golgi apparatus
- Absent or rare in plant cells (vacuole does similar work)

Ribosomes

"Protein factory of the cell"

- Site of protein synthesis (translation of mRNA)
- Prokaryotes + Mitochondria + Chloroplast: **70S**
- Eukaryotic cytoplasm: **80S** (60S + 40S subunits)
- Composed of rRNA + proteins; no membrane
- Discovered by George Palade (1955)

Vacuole

"Storage tank of the cell"

- Plants: large central vacuole (up to 90% cell volume in mature cell)
- Maintains turgor pressure (rigidity of plant organs)
- Animals: small, temporary vacuoles (food, contractile)
- Contractile vacuole in Amoeba/Paramecium: osmoregulation

🧠 **Organelle Nicknames — NDA loves these:**

Powerhouse = **Mitochondria** | Kitchen = **Chloroplast** | Suicide bag = **Lysosome**

Post office = **Golgi apparatus** | Protein factory = **Ribosomes** | Brain = **Nucleus**

Highway = **Endoplasmic Reticulum** | Gatekeeper = **Cell Membrane**

PYQ

Topic-Wise PYQs — Cell Organelles

Q4. Which organelle is known as the "powerhouse of the cell"?

A. Ribosome

B. Nucleus

C. Mitochondria

D. Golgi apparatus

Answer: C — Mitochondria. Mitochondria produce ATP (adenosine triphosphate) through cellular respiration, making them the primary energy source of the cell. The inner membrane folds (cristae) greatly increase the surface area for ATP synthesis.

Q5. The Golgi apparatus is primarily responsible for:

A. Protein synthesis

B. ATP production

C. Modification and packaging of proteins for secretion

D. DNA replication

Answer: C. The Golgi apparatus receives proteins from the rough ER, modifies them (adds sugar chains, sorts them), packages them into vesicles, and sends them to their destinations — inside the cell or for secretion. It acts like the cell's post office.

Q6. Lysosomes are also called "suicide bags" because:

A. They produce energy during cell death

B. They rupture and release digestive enzymes that destroy the cell

C. They contain genetic material that self-destructs

D. They are formed during apoptosis only

Answer: B. Lysosomes contain powerful hydrolytic (digestive) enzymes. When a cell is damaged or dying, lysosomes rupture and release these enzymes, which digest the cell's own contents — a process called autolysis. This earned them the name "suicide bag." Discovered by Christian de Duve.

Q7. Ribosomes in mitochondria are similar to ribosomes in:

A. Eukaryotic cytoplasm (80S)

B. Prokaryotic cells (70S)

C. Nucleus (40S)

D. Golgi apparatus

> **Answer: B — Prokaryotic cells (70S).** Both mitochondria and chloroplasts contain 70S ribosomes — identical in size to bacterial ribosomes. This is the key evidence for the Endosymbiotic Theory (Lynn Margulis), which proposes that these organelles originated from ancient bacteria engulfed by early eukaryotic cells.

TRICKY

🧐 Organelle Traps — Watch These

⚠️ **"Chloroplast and mitochondria have their own DNA — does that make them prokaryotes?"**

> **Key:** No — they are not prokaryotes. They are organelles within eukaryotic cells. However, the fact that they possess their own circular DNA and 70S ribosomes strongly supports the Endosymbiotic Theory — that they evolved from ancient prokaryotic bacteria that were engulfed and formed a symbiotic relationship. NDA may frame this as: "Which organelle contains its own genetic material?" Answer: **Both mitochondria AND chloroplast.**

⚠️ **"Mature human RBCs have no nucleus — are they dead?" NDA can ask this as a statement-true/false.**

> **Key:** Mature mammalian RBCs (Red Blood Cells) have no nucleus, no mitochondria, and no most organelles — they are pushed out during development to make more room for haemoglobin. They are still living cells, carrying out their function for ~120 days. This is unique to mammals; birds and reptiles have nucleated RBCs.

3. Tissues — Plant and Animal

3.1 Plant Tissues

Meristematic vs Permanent — a recurring NDA topic, especially with examples

🌍 Meristematic Tissue (Dividing)

Apical meristem, Lateral meristem (Cambium), Intercalary meristem

- Actively dividing cells; responsible for plant growth
- **Apical meristem:** tips of roots & shoots → primary growth (elongation)
- **Lateral meristem (Cambium):** sides of stem → secondary growth (girth/thickness)
- **Intercalary meristem:** base of leaves/internodes (e.g. grass) → regrowth after grazing
- Cells are small, isodiametric, thin-walled, densely cytoplasmic
- No vacuoles or very small; no intercellular spaces

🌳 Permanent Tissue (Non-dividing)

Parenchyma, Collenchyma, Sclerenchyma, Xylem, Phloem

- Derived from meristematic tissue; have lost ability to divide
- **Parenchyma:** thin-walled; storage and basic functions; forms bulk of plant body
- **Collenchyma:** unevenly thick walls; provides flexibility and support (celery strings)
- **Sclerenchyma:** dead at maturity; thick lignified walls; provides rigid support (coconut husk fibres)
- **Xylem:** conducts water upward; dead cells (tracheids, vessels)
- **Phloem:** conducts food (sugars) both ways; living cells

📌 Xylem vs Phloem — NDA Favourite Pair:

Xylem: water + minerals, **upward only**, dead cells, made of tracheids & vessels

Phloem: food (sugars), **bidirectional**, living cells, made of sieve tubes & companion cells

Together they form the **vascular bundle** — the plant's transport system.

3.2 Animal Tissues — Four Main Types

Location + one key function for each subtype — sufficient for NDA

Epithelial Tissue

Skin, gut lining, lung alveoli, kidney tubules

- Covers body surfaces and lines cavities
- Tightly packed cells with little intercellular substance
- **Simple squamous:** thin flat cells; diffusion (alveoli, blood vessels)
- **Cuboidal:** cube-shaped; secretion & absorption (kidney tubules, glands)

Connective Tissue

Bone, blood, cartilage, tendons, ligaments, adipose tissue

- Connects, supports, and binds other tissues
- Cells dispersed in extracellular matrix (ECM)
- **Blood:** fluid connective tissue (plasma + cells)

- **Columnar:** tall cells; absorption (intestine lining); may have cilia
- **Stratified squamous:** multiple layers; protection (skin)

- **Bone:** most rigid CT; matrix of calcium phosphate
- **Cartilage:** flexible; no blood supply; matrix of chondroitin
- **Tendon:** connects muscle to bone; **Ligament:** bone to bone

💪 Muscular Tissue

Biceps, heart wall, gut wall, iris of eye

- **Striated (Skeletal):** voluntary; multinucleate; attached to bones
- **Smooth (Involuntary):** non-striated; uninucleate; gut, blood vessels
- **Cardiac:** striated but involuntary; branched cells; intercalated discs; heart only
- Cardiac muscle never fatigues; always rhythmic
- Smooth muscle: slowest contraction; most sustained

Nervous Tissue

Brain, spinal cord, peripheral nerves

- Receives and transmits electrical signals
- Neuron = structural & functional unit; does NOT divide after birth
- **Cell body (soma):** contains nucleus
- **Dendrites:** receive signals; **Axon:** transmit signals away
- Myelin sheath speeds up nerve impulse
- Glia cells (astrocytes, microglia): support neurons; DO divide

🧠 **Tendon vs Ligament (NDA classic confusion):**
Tendon connects **Muscle → Bone** (T for Tight, M to B)
Ligament connects **Bone → Bone** (L for Linking bones)
Both are dense fibrous connective tissue; both made of collagen fibres; tendons are less elastic.

PYQ

Topic-Wise PYQs — Tissues

Q8. Which of the following is a fluid connective tissue?

A. Cartilage

B. Blood

C. Bone

D. Adipose tissue

Answer: B — Blood. Blood is classified as a fluid connective tissue because it has a fluid matrix (plasma) and contains cells (RBCs, WBCs, platelets) that are suspended

in it. Bone and cartilage are rigid or semi-rigid connective tissues. Adipose tissue stores fat.

Q9. Cardiac muscle is different from skeletal muscle in that it is:

A. Non-striated and voluntary

B. Striated and involuntary

C. Non-striated and involuntary

D. Striated and voluntary

Answer: B — Striated and involuntary. Cardiac muscle has striations (like skeletal muscle) but is NOT under voluntary control (like smooth muscle). It is unique — the only striated involuntary muscle. Its cells are branched and connected by intercalated discs for synchronised contractions.

Q10. The apical meristem in plants is responsible for:

A. Increase in girth (thickness)

B. Primary growth in length

C. Regeneration after injury

D. Formation of bark

Answer: B — Primary growth in length. Apical meristem is located at the tips of roots and shoots and is responsible for elongation (primary growth). Lateral meristem (cambium) causes secondary growth (increase in girth). Intercalary meristem (at leaf base/internodes) helps regrowth after grazing.

TRICKY

🧐 Tissue Traps

⚠️ **"Neurons cannot divide — so are they permanent tissue?" NDA can twist this concept.**

Key: Neurons (nerve cells) are highly specialised and do NOT divide after birth in most regions of the brain. This is why brain injuries are often permanent. However, glial cells (supporting cells of the nervous system) CAN divide. NDA may ask: "Which

cells of the nervous system can undergo mitosis?" — Answer: Glial cells / Schwann cells, NOT neurons.

⚠️ **"Xylem conducts water only upward — true or false?"**

Key: TRUE for xylem — water and dissolved minerals travel from root → stem → leaves via xylem, always upward (unidirectional). **Phloem is bidirectional** — it carries sucrose from leaves downward to roots and also upward to growing tips. This phloem bidirectionality is a repeated NDA concept. Mechanism: xylem = transpiration pull; phloem = pressure flow.

4. Cell Division — Cell Cycle, Mitosis & Meiosis

4.1 The Cell Cycle

Interphase (longest phase) + M phase (mitosis/meiosis) — know the sub-phases of interphase

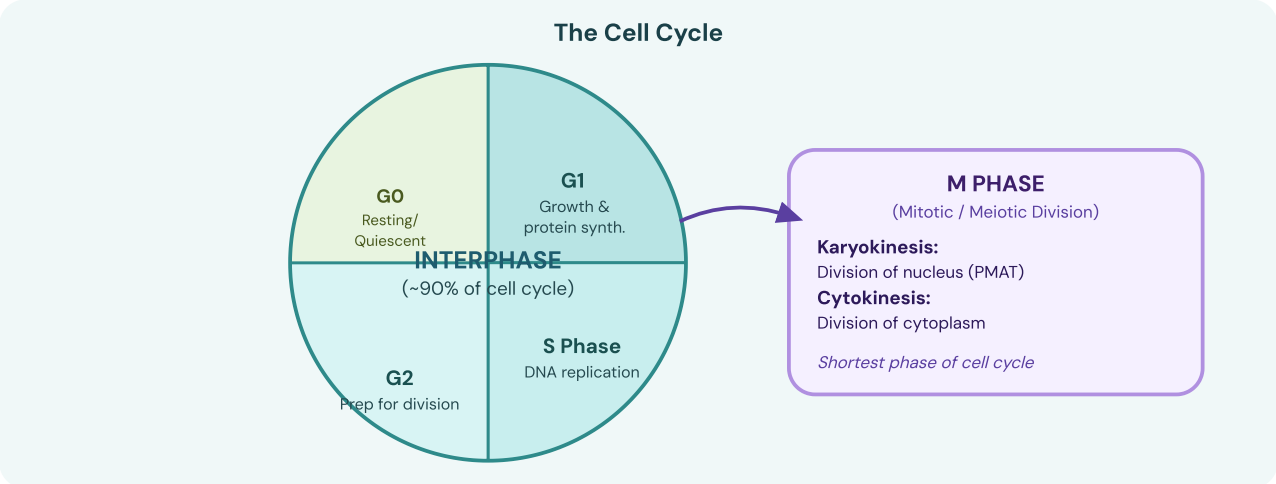

Fig. 2 — The Cell Cycle: Interphase (G1 → S → G2) occupies ~90% of the cycle. G0 is the resting phase (e.g. neurons). M phase = actual division (Karyokinesis + Cytokinesis).

📚 G1 Phase (Gap 1)

- Cell grows in size
- Proteins and RNA synthesised
- Organelles replicate

📚 S Phase (Synthesis)

- DNA replication occurs
- DNA content doubles (2N → 4N)

📚 G2 Phase (Gap 2)

- Cell continues to grow
- Proteins for spindle synthesised
- Final preparations

- Longest sub-phase in most cells
- Cell checks if ready to divide (checkpoint)

- Histone proteins synthesised
- Chromosome number stays same
- Each chromosome becomes 2 chromatids

for division
- DNA repair if errors found
- Shortest of the three interphase sub-phases

4.2 Mitosis — Phases and Events (PMAT)

Each phase has a visible event — NDA tests which event occurs in which phase

INTERPHASE (Prep)

DNA replication complete. Chromosomes not yet visible (chromatin form). Centrioles duplicate. Cell at maximum metabolic activity. **Key:** chromosomes are NOT visible in interphase — a common NDA trap.

PROPHASE (P)

Chromosomes condense and become visible. Spindle fibres begin to form. Nuclear envelope starts to dissolve. Nucleolus disappears. Centrioles move to opposite poles. *Mnemonic: P = Prepare and Pack chromosomes.*

METAPHASE (M)

Chromosomes align at the cell equator (metaphase plate). Spindle fibres attach to centromeres. This is the best phase to count and study chromosomes (most condensed, clearly visible). *Mnemonic: M = Middle.*

ANAPHASE (A)

Sister chromatids separate and move to opposite poles. Centromeres split. Cell elongates. Chromatids are pulled by spindle fibres. *Mnemonic: A = Apart — chromatids move Apart.* Chromosome number briefly appears doubled.

TELOPHASE (T)

Chromosomes reach poles; nuclear envelope reforms. Chromosomes decondense. Nucleolus reappears. Spindle fibres disappear. Cytokinesis begins (cleavage furrow in animal; cell plate in plant). *Mnemonic: T = Two nuclei formed.*

Before mitosis: 2N (diploid) → After mitosis: 2 × 2N (two diploid cells)

Human: 46 → 46 + 46

Significance of Mitosis:

(1) Growth of multicellular organisms from a single cell (zygote)

(2) Repair and regeneration of worn-out cells (skin, gut lining)

(3) Vegetative reproduction in plants (clones)

(4) Maintains chromosome number (daughter cells = parent cell in chromosome number)

(5) Asexual reproduction in unicellular organisms

4.3 Meiosis — Reductive Division

Two successive divisions; produces haploid gametes — NDA asks about Meiosis I crossing over

MEIOSIS I (Reductive)

Homologous chromosome pairs separate. During Prophase I: **crossing over** occurs at chiasmata — exchange of segments between homologous chromosomes → genetic variation. Result: 2 haploid cells (N). This is the most complex and most tested division in meiosis.

MEIOSIS II (Equational)

Similar to mitosis. **Sister chromatids separate.** No DNA replication between Meiosis I and II. Result: 4 haploid cells (N). In humans: 4 cells each with 23 chromosomes. In males → 4 sperms; in females → 1 egg + 3 polar bodies.

Before Meiosis: 2N (46 in human) → After Meiosis: 4 × N (23 each)

Total DNA: halved

📚 Key Events of Meiosis I Prophase

- **Leptotene:** chromosomes start condensing
- **Zygotene:** homologous chromosomes pair (synapsis); bivalent forms
- **Pachytene:** crossing over occurs at chiasmata
- **Diplotene:** homologs begin to separate; chiasmata visible
- **Diakinesis:** chromosomes fully condensed; nuclear envelope dissolves

🍀 Significance of Meiosis

- Maintains chromosome number across generations (gametes = N; after fertilisation = 2N)
- Crossing over creates genetic variation → raw material for evolution
- Forms gametes (sperm, eggs) for sexual reproduction
- Independent assortment of chromosomes → further variation
- Occurs in: gonads (testes, ovaries), pollen mother cells, ovule mother cells

Feature	Mitosis	Meiosis
Number of divisions	One	Two (Meiosis I + II)

Cells produced	2 daughter cells	4 daughter cells (gametes)
Chromosome number	Same as parent (2N → 2N)	Half of parent (2N → N)
Genetic identity	Genetically identical (clones)	Genetically variable
Crossing over	Does NOT occur	Occurs in Prophase I
Occurs in	All somatic (body) cells	Gonads (sex organs only)
Purpose	Growth, repair, reproduction	Gamete formation (sexual reproduction)
Human example	Skin cell division: 46 → 46 + 46	Sperm/egg formation: 46 → 23

PYQ

Topic-Wise PYQs — Cell Division

Q11. In which phase of mitosis are chromosomes best studied (most clearly visible)?

A. Prophase

B. Anaphase

C. Metaphase

D. Telophase

Answer: C — Metaphase. During Metaphase, chromosomes are maximally condensed (shortest and thickest) and aligned at the equatorial plate (metaphase plate). This makes them clearly visible and easy to count. This is why karyotyping (chromosome study) uses metaphase spreads.

Q12. Crossing over during meiosis is significant because it:

A. Reduces chromosome number by half

B. Creates genetic variation by exchanging segments between homologous chromosomes

C. Produces four identical gametes

D. Occurs during S phase of interphase

Answer: B. Crossing over (recombination) occurs during Prophase I of Meiosis at structures called chiasmata. Segments of maternal and paternal chromosomes are

exchanged, creating new combinations of alleles. This is the primary source of genetic variation — essential for evolution and was identified by Morgan and Bridges.

Q13. DNA replication occurs during which phase of the cell cycle?

A. G1 phase

B. G2 phase

C. S phase

D. M phase

Answer: C — S phase (Synthesis phase). The S phase is specifically dedicated to DNA synthesis (replication). The DNA content doubles during this phase (2C → 4C), even though the chromosome number does not change. Each chromosome now consists of two identical sister chromatids joined at the centromere.

Q14. The number of chromosomes in a human sperm cell is:

A. 46

B. 23

C. 92

D. 48

Answer: B — 23. Human somatic (body) cells are diploid (2N = 46 chromosomes). Gametes (sperm and egg) are haploid (N = 23), formed by meiosis. At fertilisation, sperm (23) + egg (23) = zygote (46). Chimpanzees have 48 chromosomes — another NDA trap.

TRICKY

🧐 Cell Division Traps

⚠️ **"After S phase, each chromosome has 2 chromatids — so the chromosome number has doubled." True or False?**

False. After S phase, the DNA content doubles (2C → 4C) but the chromosome NUMBER stays the same. Each chromosome now consists of two sister chromatids joined at the centromere — they are still counted as ONE chromosome. The chromosome number only doubles transiently during Anaphase (when centromeres split), and then returns to normal when daughter cells are formed. NDA often tests:

"After S phase, how many chromosomes does the cell have?" Answer: Same as before (e.g., 46 in human).

⚠️ **"Meiosis II is similar to mitosis" — In what way? NDA asked this as a match-the-statement question.**

Key: Meiosis II is called the equational division because, like mitosis, sister chromatids separate to opposite poles (not homologous chromosomes like in Meiosis I). However, the key difference is that Meiosis II starts with haploid cells (N), not diploid cells. No DNA replication occurs between Meiosis I and II. So it resembles mitosis in mechanism but is NOT the same in ploidy level of starting/ending cells.

Quick-Reference Fact Sheet — BN02

🔵 Prokaryote vs Eukaryote Keys

- Prokaryote: NO nuclear membrane, NO membrane-bound organelles, 70S ribosomes
- Eukaryote: TRUE nucleus, membrane-bound organelles, 80S ribosomes
- Plasmid: present in prokaryotes only
- Mitochondria & Chloroplast: 70S ribosomes (like prokaryotes)
- Bacteria + Cyanobacteria = only prokaryotes

⚡ Organelle Nicknames (NDA Favourite)

- Mitochondria = Powerhouse (ATP production)
- Lysosome = Suicide bag (autolysis)
- Chloroplast = Kitchen (photosynthesis)
- Golgi = Post office (packaging & secretion)
- Ribosome = Protein factory (translation)
- Nucleus = Brain / Control centre
- ER = Transport highway

🌍 Plant vs Animal Cell

- ONLY plant: Cell wall (cellulose), Chloroplast, Large vacuole, Plasmodesmata
- ONLY animal: Centriole, Lysosomes more prominent

💪 Animal Tissue Types

- Epithelial: covers surfaces; squamous, cuboidal, columnar
- Connective: bone, blood, cartilage, tendon, ligament

- Both: Nucleus, Mitochondria, ER, Golgi, Ribosomes
- RER → protein synthesis; SER → lipid synthesis
- Mature RBC: no nucleus, no mitochondria (mammal only)

- Muscular: skeletal (voluntary), smooth (involuntary), cardiac (striated + involuntary)
- Nervous: neuron (no division) + glia (divides)
- Tendon: muscle→bone; Ligament: bone→bone

🌿 Plant Tissue Types

- Meristematic: dividing; apical (length), lateral/cambium (girth), intercalary
- Permanent simple: parenchyma (storage), collenchyma (flexible support), sclerenchyma (rigid)
- Permanent complex: Xylem (water, upward), Phloem (food, bidirectional)
- Xylem = dead cells; Phloem = living cells

🔄 Cell Division Numbers

- Mitosis: 2N → 2N (same); 2 cells; somatic cells
- Meiosis: 2N → N (half); 4 cells; gonads only
- Human somatic: 46 (2N); Human gamete: 23 (N)
- Crossing over: Prophase I of Meiosis only
- Chromosome best seen: Metaphase (most condensed)
- DNA doubles in: S phase (not M phase)
- Best phase to count chromosomes: Metaphase

⚡ Quick Revision Booster — BN02

🔵 Prokaryote vs Eukaryote

- No nuclear membrane = prokaryote
- 70S ribosome = prokaryote (also mitochondria, chloroplast)
- 80S = eukaryotic cytoplasm

⚡ Organelle One-Liners

- Powerhouse = Mitochondria
- Suicide bag = Lysosome
- Post office = Golgi apparatus
- Kitchen = Chloroplast

🌿 Plant vs Animal Cell

- Centriole only in animal cell
- Chloroplast only in plant cell
- Large vacuole: plant; small: animal
- Cell wall: plant (cellulose); absent in

- Only prokaryotes have plasmids
- All bacteria + cyanobacteria = prokaryotes

- Protein factory = Ribosome

animal

- Mature RBC: no nucleus (mammal)

💪 Tissue Shortcuts

- Fluid connective tissue = Blood
- Cardiac = striated + involuntary (unique)
- Tendon: muscle→bone; Ligament: bone→bone
- Neuron: cannot divide after birth
- Apical = length; Lateral = girth

🔁 Mitosis Shortcuts

- PMAT = Prophase → Metaphase → Anaphase → Telophase
- Metaphase = best to count/study chromosomes
- Anaphase = chromatids pulled Apart
- Result: 2 diploid cells (2N → 2N)
- DNA doubles in S phase; chromosomes visible in M phase

🔁 Meiosis Shortcuts

- Crossing over: Prophase I only
- Result: 4 haploid cells (N)
- Meiosis II = equational (like mitosis)
- Human: 46 → 4 cells of 23
- Meiosis only in gonads (testes/ovaries)