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Cell Cycle and Cell Division Class 11 Notes | CBSE

Biology Chapter 10

Cell Cycle and Cell Division is Chapter 10 of CBSE Class 11 Biology — the chapter that explains how a single fertilised egg becomes a trillion-celled human, and how the next generation inherits exactly the right number of chromosomes. Every time you heal a cut, grow taller, or make a gamete, one of the two divisions in this chapter is doing the work. Master it and you have unlocked the foundation for all of Class 12 Genetics and Reproduction.

By the end of these notes you will be able to walk through the four phases of the cell cycle, name every stage of mitosis and meiosis in order, list the five sub-stages of prophase I, and answer the classic “mitosis vs meiosis” comparison without hesitation. This is a high-weightage chapter carrying roughly 5–6 marks in boards and 3–5 questions in NEET, and a direct prerequisite for inheritance, variation, and human reproduction.

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Key Concepts

1. The Cell Cycle

The **cell cycle** is the sequence of events by which a cell duplicates its contents (DNA, organelles) and divides into two daughter cells. It is the orderly “growth-then-division” loop that every dividing cell follows.

A typical human cell takes about **24 hours** to complete one cycle, while a yeast cell may take only about 90 minutes. The cycle has two broad parts: a long **interphase** (preparation) and a short **M phase** (actual division).

Two Main Phases

- **Interphase:** the resting-but-busy phase where the cell grows and copies its DNA — covers about 95% of the cycle.
 - **M phase (Mitotic phase):** the phase in which the nucleus and cytoplasm actually divide.
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2. Phases of Interphase (G_1 , S, G_2)

Interphase is the longest part of the cycle and is split into three sub-phases. The DNA is copied only once, in the S phase.

Phase	What Happens
G_1 (Gap 1)	Cell is metabolically active, grows in size, makes RNA and proteins. DNA is NOT replicated.
S (Synthesis)	DNA replication occurs — the amount of DNA doubles ($2n$ DNA becomes $4n$ DNA), but chromosome number stays the same.
G_2 (Gap 2)	Cell continues to grow; proteins and organelles needed for division are synthesised.

Key idea: In the S phase the DNA content doubles, but the chromosome *number* does not change — each chromosome now has two sister chromatids.

The G_0 (Quiescent) Stage

Cells that do not divide further (like mature nerve cells) exit the cycle at G_1 and enter an inactive stage called G_0 . They stay metabolically active but stop dividing.

3. M Phase and Mitosis (Equational Division)

Mitosis is the division of the nucleus that produces two daughter cells genetically identical to the parent, each with the same chromosome number. It is also called **equational division** because the chromosome number is conserved ($2n \rightarrow 2n$).

It occurs in somatic (body) cells and is responsible for growth, repair, and replacement of worn-out cells. Mitosis is divided into four stages: prophase, metaphase, anaphase, and telophase.

4. Prophase

Prophase is the first stage of mitosis, marking the end of interphase.

- Chromatin condenses into compact, visible **chromosomes**, each made of two sister chromatids joined at the centromere.
- The **centrioles** move to opposite poles and begin forming the **spindle fibres**.
- The **nuclear envelope and nucleolus disappear** by the end of prophase.

[DIAGRAM: A cell in prophase — condensed chromosomes with two chromatids each, centrioles at opposite poles, spindle fibres beginning to form, no nuclear membrane.]

5. Metaphase

Metaphase is the stage of maximum chromosome condensation, ideal for studying chromosome morphology.

- Chromosomes line up at the centre of the cell along the **metaphase plate** (equator).
- Spindle fibres attach to the **kinetochore** on the centromere of each chromosome.
- Chromosomes are most condensed and clearly visible here.

Key idea: The alignment of chromosomes at the equatorial plate is the defining feature of metaphase.

6. Anaphase

Anaphase is the shortest stage, where the sister chromatids finally separate.

- The **centromeres split**, and the two sister chromatids of each chromosome separate.
 - Each chromatid (now a daughter chromosome) moves towards opposite poles, pulled by the shortening spindle fibres.
 - The centromere leads and the arms trail behind.
-

7. Telophase and Cytokinesis

Telophase is essentially prophase in reverse — the cell rebuilds two nuclei.

- Chromosomes reach the poles and **decondense** back into chromatin.
- The **nuclear envelope and nucleolus reappear** around each set of chromosomes.
- The spindle fibres disappear.

Cytokinesis

Cytokinesis is the division of the cytoplasm that completes cell division, producing two separate daughter cells.

- In **animal cells**: a **cleavage furrow** pinches the cell inward from the membrane.
 - In **plant cells**: a **cell plate** forms from the centre outward (because of the rigid cell wall).
-

8. Significance of Mitosis

Mitosis is the basis of growth and maintenance of multicellular bodies.

- **Growth:** increases the number of cells, helping organisms grow.
 - **Repair and replacement:** replaces worn-out cells of skin, blood, and the gut lining.
 - **Genetic stability:** daughter cells are genetically identical to the parent (no variation).
 - **Cell-size restoration:** keeps the nucleo-cytoplasmic ratio constant.
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9. Meiosis (Reductional Division)

Meiosis is the division that halves the chromosome number, producing four haploid (n) daughter cells from one diploid ($2n$) parent cell. It is also called **reductional division** because $2n$ becomes n .

It occurs only in the reproductive (germ) cells during gamete formation, and it ensures that the chromosome number stays constant from generation to generation. Meiosis has **two successive divisions** — meiosis I and meiosis II — but DNA replicates only **once**, before meiosis I.

10. Meiosis I — Reductional Division

Meiosis I is where the actual reduction in chromosome number happens, when homologous chromosomes separate.

Prophase I — Five Sub-stages

Prophase I is the longest and most complex phase, divided into five sub-stages (remember: **Lazy Zebras Practise Diving Daily**).

Sub-stage	Key Event
Leptotene	Chromosomes condense and become visible as thin threads.
Zygotene	Homologous chromosomes pair up — called synapsis ; each pair forms a bivalent (or tetrad).
Pachytene	Crossing over occurs — exchange of segments between non-sister chromatids at the chiasmata; the chief source of variation.
Diplotene	Homologues begin to separate but stay joined at points called chiasmata .
Diakinesis	Chiasmata terminalise, nucleolus disappears, nuclear envelope breaks down — cell is ready for metaphase I.

Rest of Meiosis I

- **Metaphase I:** bivalents align at the equator; spindle fibres attach to the homologous chromosomes.
- **Anaphase I:** homologous chromosomes separate and move to opposite poles, but sister chromatids stay together (centromeres do NOT split).
- **Telophase I:** nuclear membrane reappears; two haploid cells form (each chromosome still has two chromatids).

Key idea: The reduction from $2n$ to n happens in anaphase I, when homologues — not chromatids — separate.

11. Meiosis II — Equational Division

Meiosis II is essentially like mitosis, separating sister chromatids, but it acts on haploid cells. There is **no DNA replication** before it.

- **Prophase II:** chromosomes condense again; nuclear envelope disappears.
- **Metaphase II:** chromosomes line up at the equator; spindle fibres attach to kinetochores.
- **Anaphase II:** centromeres split and sister chromatids separate to opposite poles.
- **Telophase II:** nuclei reform; cytokinesis gives a total of **four haploid daughter cells**.

12. Significance of Meiosis

Meiosis is the engine of both genetic constancy and genetic variation.

- **Maintains chromosome number:** halving in gametes means fertilisation restores the diploid number — the number stays constant across generations.
- **Genetic variation:** crossing over (pachytene) and independent assortment of chromosomes shuffle genes, driving evolution.
- **Gamete formation:** produces haploid sperm and eggs.
- **Basis of inheritance:** the recombination here is the foundation of the laws of genetics you will study in Class 12.

13. Mitosis vs Meiosis — Comparison

Feature	Mitosis	Meiosis
Where it occurs	Somatic (body) cells	Germ (reproductive) cells
Number of divisions	One	Two (meiosis I & II)
Daughter cells	2	4
Chromosome number	Stays the same ($2n \rightarrow 2n$)	Halved ($2n \rightarrow n$)
Crossing over	Absent	Present (pachytene)
Genetic result	Identical to parent	Genetically variable
Purpose	Growth, repair	Gamete formation, variation

Weightage in Board & Entrance Exams

Exam	Typical Weightage	Most-Tested Areas
CBSE Board (Class 11)	5–6 marks	Phases of cell cycle, stages of mitosis, prophase I sub-stages, mitosis vs meiosis
NEET	3–5 questions	Prophase I stages, significance of meiosis, DNA content per phase, cytokinesis
CUET / State CETs	2–3 questions	Definitions, comparison table, G ₀ stage, crossing over

[TABLE: Question-type split — VSA (1 mark): definitions & phase identification; SA (2–3 marks): significance, prophase I stages, cytokinesis difference; LA (5 marks): full mitosis or meiosis description, mitosis vs meiosis comparison.]

Important Definitions

Term	Definition
Cell cycle	Sequence of growth and division by which a cell duplicates and divides into two
Interphase	Preparatory phase (G ₁ , S, G ₂) where the cell grows and replicates DNA
S phase	Phase of interphase in which DNA replication doubles the DNA content
G ₀ stage	Quiescent stage in which a cell stops dividing but stays metabolically active
Mitosis	Equational nuclear division giving two genetically identical diploid cells
Cytokinesis	Division of the cytoplasm that completes cell division
Meiosis	Reductional division giving four haploid cells from one diploid cell
Synapsis	Pairing of homologous chromosomes during zygotene of prophase I
Bivalent (tetrad)	A paired structure of two homologous chromosomes (four chromatids)
Crossing over	Exchange of segments between non-sister chromatids at the chiasmata (pachytene)

Illustrative Examples

Example 1

A cell has 24 chromosomes in G₁. How many chromosomes and how many DNA molecules will it have at the end of the S phase?

Answer: Chromosome number stays **24**, but DNA doubles — so there are now 24 chromosomes each with 2 chromatids, i.e. **48 DNA molecules**.

Example 2

A diploid plant cell with $2n = 16$ undergoes meiosis. How many chromosomes will each of the four daughter cells have?

Answer: Meiosis halves the number, so $n = 16/2 = \mathbf{8 \text{ chromosomes}}$ in each of the four haploid cells.

Example 3

In which sub-stage of prophase I does crossing over occur, and what structure holds the homologues together afterwards?

Answer: Crossing over occurs in **pachytene**; the homologues remain held at **chiasmata** (visible in diplotene).

Example 4

How many cell divisions and how many daughter cells result from one round of mitosis and one round of meiosis?

Answer: Mitosis = **1 division → 2 cells**. Meiosis = **2 divisions → 4 cells**.

Example 5

If a human somatic cell ($2n = 46$) divides by mitosis, how many chromosomes will each daughter cell have?

Answer: Mitosis is equational, so each daughter cell has **46 chromosomes** (the same as the parent).

Example 6

Name the stage of mitosis in which (a) chromosomes align at the equator and (b) sister chromatids separate.

Answer: (a) **Metaphase** — alignment at the metaphase plate; (b) **Anaphase** — centromeres split and chromatids move to opposite poles.

Important Questions for Board Exams

1-Mark Questions (VSA)

1. In which phase of the cell cycle does DNA replication occur?
2. What is the G_0 stage of the cell cycle?
3. Name the structure that joins two sister chromatids.
4. In which sub-stage of meiosis does crossing over take place?
5. How does cytokinesis differ in plant and animal cells?

2–3-Mark Questions (SA)

1. List the three phases of interphase and state the main event of each.
2. Why is meiosis called a reductional division? Explain with chromosome numbers.
3. State any three points of significance of mitosis.
4. Describe the events of anaphase in mitosis.

5-Mark Questions (LA)

1. Describe the five sub-stages of prophase I of meiosis in sequence, highlighting the events in each.
 2. Compare mitosis and meiosis under at least five distinguishing features.
 3. Explain the four stages of mitosis (prophase to telophase) and the process of cytokinesis.
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Quick Revision Points

- Cell cycle = Interphase (G_1 , S, G_2) + M phase; interphase is ~95% of the cycle
 - DNA replicates only in S phase — DNA doubles, chromosome number stays the same
 - G_0 = quiescent, non-dividing but active stage
 - Mitosis: P-M-A-T → 2 identical diploid cells (equational, $2n \rightarrow 2n$)
 - Metaphase = chromosomes at equator; Anaphase = chromatids separate
 - Cytokinesis: cleavage furrow (animal), cell plate (plant)
 - Mitosis is for growth, repair, and replacement; no variation
 - Meiosis = 2 divisions → 4 haploid cells (reductional, $2n \rightarrow n$)
 - Prophase I stages: Leptotene → Zygotene → Pachytene → Diplotene → Diakinesis
 - Crossing over (pachytene) + independent assortment = source of variation
 - Reduction ($2n \rightarrow n$) happens in anaphase I; chromatids separate in anaphase II
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Next Chapter: Chapter 11 — Transport in Plants



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