KSQUARE CAREER INSTITUTE

CELL CYCLE AND CELL DIVISION

Class 11 Biology • Lecture 01: Cell Cycle & Mitosis (Karyokinesis) • NEET Notes

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Lecture at a Glance

1. Introduction — what is inside the cell; packaging of DNA (nucleosome)
2. Cell division & cell cycle — definition, duration, phases
3. Interphase — G_1, S, G_2; G_0 (quiescent stage)
4. M-phase — types of cell division (mitosis, meiosis, amitosis)
5. Mitosis — prophase, metaphase, anaphase, telophase; plant vs animal cells
6. Added: cytokinesis, significance of mitosis, meiosis overview, comparison table, practice MCQs

INTRODUCTION

- All organisms, even the largest, start life from a **single cell**. Growth and reproduction are characteristics of cells; every cell reproduces by **dividing into two** (parental cell → two daughter cells), which can themselves grow and divide.
- Cycles of growth and division let a single cell form a structure of **millions of cells**. How many times a cell divides is already present in its **genetic information**.
- Inside the cell: **cell → nucleus → chromosome → DNA → gene** (segment of DNA).

Packaging of DNA

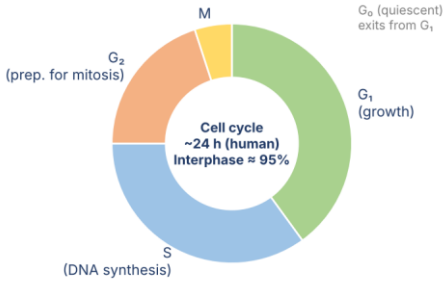
- Each of us has enough DNA to reach from here to the sun and back more than 300 times — it is packed tightly into chromosomes inside a tiny nucleus.
- DNA wraps around a **histone octamer** → **nucleosome** ('beads on string', beaded structure) → chromatin fibre → further condensation → duplicated chromosome.

CELL DIVISION & CELL CYCLE

- Growth and reproduction of all organisms depend on **division and enlargement of cells**; the mechanisms together constitute **cell reproduction**.

Cell cycle

The **sequence of events** by which a cell **duplicates its genome, synthesises other constituents** of the cell and eventually **divides into two daughter cells**.



Phase	Nature	Stages
Interphase	**Preparatory** phase (between two successive M-phases)	G_1, S, G_2
M-phase	**Multiplication** phase (actual division)	Karyokinesis (prophase → metaphase → anaphase → telophase) + cytokinesis

- Duration varies with organism and cell type: a typical **human cell ≈ 24 h**; **yeast ≈ 90 min**.

Points to remember (class notes)

A cell that enters G_1 is **diploid**.

The cell cycle is the **life of a cell**.

Cell division is **more complicated in eukaryotes** than in prokaryotes.

Events of the cell cycle are under **genetic control**.

INTERPHASE

- Occupies **~95% of the cell cycle**; long, biosynthetic, **non-dividing** phase during which cell organelles and DNA duplicate.

Stage	Also called	Events
G_1 phase	Pre-DNA synthesis / **post-mitotic** gap	Cell **grows in size**; synthesis of ATP, proteins, amino acids, RNA; most organelles duplicate; metabolically active
S phase	**DNA synthesis** phase	**DNA replicates** — amount of DNA doubles (2C → 4C) but **chromosome number stays the same (2n)**; **centriole duplicates** (animal cells, in cytoplasm); **histone proteins** are synthesised
G_2 phase	Post-DNA replication / **pre-mitotic** gap	Cell continues to grow; synthesis of **tubulin proteins** (for spindle), ATP, RNA; mitochondria, chloroplasts and Golgi bodies duplicate

G_0 Phase — Quiescent Stage

- Cells that do not divide further exit G_1 and enter G_0 — **non-dividing but metabolically active**; they can re-enter the cycle when needed (e.g. heart cells remain in G_0).

M-PHASE & TYPES OF CELL DIVISION

- The phase in which **actual cell division** occurs.

Type	Features	Examples
Mitosis	Equational division; somatic cells	Most body cells
Meiosis	Reductional division; gamete formation	Germ cells
Amitosis (direct division)	Direct karyokinesis **without spindle formation**; **nuclear membrane remains intact**; followed by cytokinesis	Bacteria, yeast (as given in class)

MITOSIS

- Cell division in **somatic cells**; called **equational division** — the chromosome number of parent and progeny cells is the **same**.
- Generally seen in **diploid** cells, but also in **haploid** cells of some lower plants and some social insects (e.g. **male honeybee**).
- Involves a major **reorganisation of all cell components**.
- **Karyokinesis** (division of the nucleus) has 4 stages: **prophase, metaphase, anaphase, telophase**.

1. Prophase

- **Longest phase** of mitosis; follows the S and G_2 phases of interphase (where DNA molecules are intertwined); chromosome number **2n**, DNA **4C**.
- Chromatin fibres **untangle and condense** to form mitotic chromosomes, each with **two chromatids** attached at the **centromere**.
- **Centrosomes** (duplicated centrioles) move to opposite poles; each radiates microtubules called **asters**; two asters + spindle fibres = **mitotic apparatus**.
- By the end of prophase the cell shows **no Golgi complex, ER, nucleolus or nuclear envelope** (all membranes dissociate).

2. Metaphase

- Nuclear envelope **completely disintegrates**; chromosomes spread through the cytoplasm.
- **Chromosome condensation is complete** — best stage to study **morphology** of chromosomes; each has two sister chromatids.
- Chromosomes lie at the **equator**; plane of alignment = **metaphase plate**.
- Spindle fibres from both poles attach to chromatids at the **kinetochores** of the centromere.

3. Anaphase

- **Shortest phase** of mitosis.

- **Centromere of each chromosome splits** longitudinally → two **daughter chromatids** (chromosomes of future daughter nuclei).
- As the spindle fibres **contract**, chromatids move from the equator to **opposite poles**.

4. Telophase (Reverse of Prophase)

- Chromosomes cluster at opposite poles and **uncoil into chromatin fibres**.
- **Nuclear envelope reassembles** → two daughter nuclei; **nucleolus, Golgi complex and ER reappear**; **spindle fibres disappear**.
- A small **invagination** of the cell membrane marks the beginning of **cytokinesis**.

Plant vs Animal Cell Mitosis

Feature	Animal cell	Plant cell
Centrosome & asters	Present	**Absent** (anastral)
Spindle origin	From centrioles	From **polymerisation of tubulin**
Cytokinesis	Furrow in cell membrane deepens inward	**Cell plate** forms (middle lamella) centrifugally

BEYOND THE LECTURE (ADDITIONAL TOPIC)

Cytokinesis

- Division of the cytoplasm after karyokinesis. If karyokinesis is not followed by cytokinesis, a **multinucleate** condition (**syncytium**) forms — e.g. **liquid endosperm of coconut**.

Significance of Mitosis

- Produces **genetically identical** diploid daughter cells; **growth** of multicellular organisms; restores nucleo-cytoplasmic ratio; **cell repair** (e.g. epidermis, gut lining, blood cells); meristems of plants grow continuously.

Meiosis — Overview

- **Reductional division** in germ cells — one round of DNA replication, **two divisions** (meiosis I & II) → **4 haploid** cells.
- **Prophase I** sub-stages: **leptotene** (condensation) → **zygotene** (**synapsis**, synaptonemal complex, bivalents/tetrads) → **pachytene** (**crossing over**, recombination nodules, recombinase) → **diplotene** (**chiasmata**; dictyotene in some oocytes) → **diakinesis** (terminalisation of chiasmata).
- Anaphase I: homologous chromosomes separate (sister chromatids stay together); meiosis II resembles mitosis.
- Significance: **conservation of chromosome number** across generations and **genetic variation** (crossing over, independent assortment).

Feature	Mitosis	Meiosis
Cells	Somatic	Germ (reproductive)

Feature	Mitosis	Meiosis
Divisions	One	Two
Daughter cells	2, diploid, identical	4, haploid, varied
Crossing over	Absent	Present (pachytene)
Pairing of homologues	Absent	Present (zygotene)

PRACTICE MCQS

Q1. The duration of the cell cycle in a typical human cell is about

(a) 90 min
(b) 12 h
(c) 24 h
(d) 48 h

Answer: (c)

Q2. DNA replication occurs in

(a) G_1
(b) S
(c) G_2
(d) M

Answer: (b)

Q3. After S phase, the chromosome number and DNA content of a diploid cell are

(a) 4n, 4C
(b) 2n, 4C
(c) 2n, 2C
(d) n, 2C

Answer: (b)

Q4. Tubulin proteins for spindle formation are synthesised in

(a) G_1
(b) S
(c) G_2
(d) G_o

Answer: (c)

Q5. The longest phase of mitosis is

(a) Prophase
(b) Metaphase
(c) Anaphase
(d) Telophase

Answer: (a)

Q6. The best stage to study chromosome morphology is

(a) Prophase
(b) Metaphase
(c) Anaphase
(d) Telophase

Answer: (b)

Q7. Splitting of the centromere occurs during

(a) Prophase
(b) Metaphase
(c) Anaphase
(d) Telophase

Answer: (c)

Q8. Spindle fibres attach to chromosomes at the

(a) Telomere
(b) Kinetochore
(c) Chromomere
(d) Satellite

Answer: (b)

Q9. Nucleolus, Golgi complex and ER reappear in

(a) Prophase
(b) Metaphase
(c) Anaphase
(d) Telophase

Answer: (d)

Q10. Cells that exit G_1 and stop dividing but remain metabolically active are in

(a) S phase
(b) G_2 phase
(c) G_o phase
(d) M phase

Answer: (c)

QUICK REVISION

- Cell cycle = genome duplication + synthesis of constituents + division; human ~24 h, yeast ~90 min.
- Interphase (~95%): G_1 (growth), S (DNA 2C→4C, 2n same; centriole duplicates; histones), G_2 (tubulin, organelles); G_o quiescent.
- M-phase: karyokinesis + cytokinesis; division types: mitosis, meiosis, amitosis (no spindle, nuclear membrane intact).
- Prophase longest (condensation, asters, membranes vanish); metaphase (metaphase plate, kinetochores, best for study); anaphase shortest (centromere splits, chromatids to poles); telophase (reverse of prophase).
- Plant cells: no centrosome/asters; spindle from tubulin; cell plate.