CAIE Biology A-level

Topic 5: The mitotic cell cycle

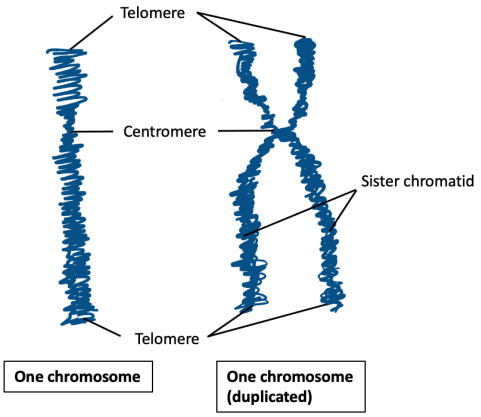
Notes

Mitosis

The role of **mitosis and the cell cycle** is to produce **identical daughter cells for growth and asexual reproduction**. All the cells produced by mitosis are **genetically identical**; therefore, **mitosis does not give rise to genetic variation**. Mitosis maintains chromosome number **(diploid → diploid)** and **genetic stability.**

Mitosis is important for:

- **Growth** of multicellular organisms
- **Replacing** dead or damaged cells
- **Repairing** damaged tissue (via cell replacement)
- **Asexual reproduction**



Structure of a chromosome

Each chromosome consists of:

- **DNA molecule:** a long, double-helix strand of deoxyribonucleic acid.
- **Histone proteins:** DNA coils tightly around histones, forming nucleosomes, which further coil to form chromatin fibres.
- **Sister chromatids:** identical copies of a DNA molecule formed after DNA replication during the S phase; joined together at a centromere.
- **Centromere:** a region in the chromosome that holds sister chromatids together and acts as the attachment point for spindle fibres during mitosis.
- **Telomeres:** repetitive DNA sequences at each end of the chromosome that protect genes from degradation and prevent the loss of coding DNA during replication.

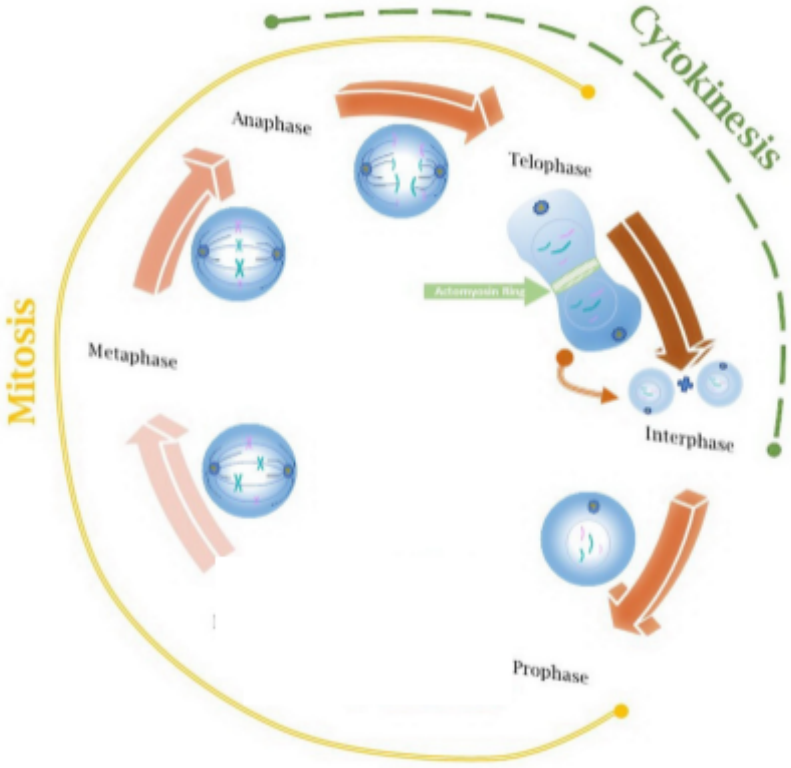
During the cell cycle, a cell is formed, grows, and then divides to form daughter cells. There are three stages of the cell cycle:

- **Interphase** – during this stage the cell **grows and then prepares to divide**; chromosomes and some organelles are replicated. Interphase consists of the G1, G2 and S phases.
    - **G1** – The cell receives signals committing it to DNA replication - the cell grows, synthesises proteins and organelles, and prepares to enter the S phase
    - **S** – DNA replication occurs, producing sister chromatids joined at the centromere
    - **G2** – The cell grows further and prepares for mitosis by synthesising spindle proteins and enzymes required for division.

- **Mitosis** – mitosis is a form of cell division that produces identical cells. There are four stages of mitosis: **prophase, metaphase, anaphase and telophase.**

Stage	Chromosome behaviour	Other key events
Prophase	Chromatin condenses into visible chromosomes, each consisting of two sister chromatids joined by a centromere.	Nucleolus disappears; centrioles (in animal cells) move to opposite poles; spindle fibres start forming from microtubules; and the nuclear envelope begins to break down.
Metaphase	Chromosomes align at the equator (metaphase plate).	Spindle fibres attach to the centromere.
Anaphase	Centromeres split, and spindle fibres shorten, pulling sister chromatids apart to opposite poles.	Each chromatid is now an independent chromosome; movement requires energy from ATP.
Telophase	Chromosomes reach poles and uncoil back into chromatin.	Nuclear envelope reforms around each set of chromosomes; nucleolus reappears; spindle disintegrates.

- **Cytokinesis** – during cytokinesis the parent and replicated organelles move to opposite sides of the cell and the **cytoplasm divides** thus producing two daughter cells.



Stem cells

Cells produced by mitosis may be undifferentiated (stem cells) and can differentiate into **specialised cells**. Stem cells repeatedly undergo cell division and are used for cell replacement and tissue repair. Once the cell becomes specialised for a specific function it stops dividing.

Types:

- **Totipotent** – can form all cell types, including extra-embryonic tissues.
- **Pluripotent** – can form all body cell types but not extra-embryonic tissues.
- **Multipotent** – can form a limited range of cells (e.g., bone marrow → blood cells).

Normally, cell division is tightly regulated by **cell cycle checkpoints** and **growth control genes**. If these controls fail, cells divide **uncontrollably**, forming a **tumour**.

Tumours may be:

- **Benign** – localised and non-invasive.
- **Malignant (cancerous)** – invade surrounding tissues and can **metastasise** via the blood or lymph system.

Key terms	Definition
Chromatid	One of two identical copies of DNA forming a duplicated chromosome.
Centromere	Point of attachment between sister chromatids; site of spindle attachment.
Spindle fibres	Microtubules that move chromosomes during mitosis.
Telomere	Repetitive sequence of non-coding DNA at chromosome ends, preventing the loss of genes from the ends of chromosomes during DNA replication.
Stem cell	Undifferentiated cell capable of self-renewal and differentiation.
Tumour	Mass of abnormally dividing cells caused by loss of growth control.