

The mitotic cell cycle

A-Level Biology 9700 · Topic 5 revision notes

Everything from the 2 lessons of this topic on a few pages: the key idea of each lesson, the diagram to remember, the points to learn and the traps examiners set. Read it, cover it, test yourself.

1. Chromosomes and the cell cycle

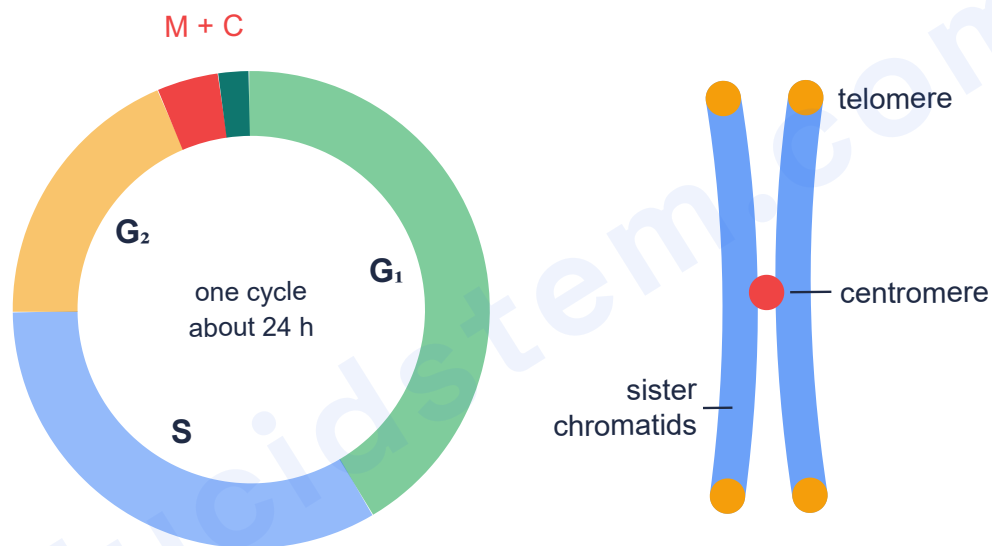
2. Chromosome behaviour in mitosis

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1 Chromosomes and the cell cycle

Syllabus 5.1

A **chromosome** is one long DNA molecule wound round **histone** proteins. In **interphase** the cell grows (G_1), replicates every DNA molecule (S) and grows and checks again (G_2); then **mitosis** divides the nucleus and **cytokinesis** divides the cytoplasm. After S phase each chromosome is two identical **sister chromatids** joined at the **centromere**, so mitosis gives two **genetically identical** daughter cells, used for growth, replacement, repair and asexual reproduction. **Telomeres** protect the chromosome ends, **stem cells** supply new cells, and division that escapes control forms a **tumour**.



DNA copied in S phase: two identical sister chromatids

Fig. 1: the mitotic cell cycle (left, to the lab's 24 h timings) and a chromosome after S phase (right)

Replication in S, division in M.

- ✓ **Chromosome:** DNA + histones; after S phase, two sister chromatids at a centromere.
- ✓ **Interphase:** G₁ growth, S DNA replication, G₂ growth and checks.
- ✓ **Mitosis:** genetically identical nuclei for growth, replacement, repair, asexual reproduction.
- ✓ **Telomeres** protect genes; **stem cells** supply new cells; mutation plus uncontrolled mitosis gives a **tumour**.

Watch out!

A chromosome is not always X-shaped. Before S phase it is a single chromatid (one DNA molecule); the X shape only appears after replication, once the chromosome has condensed for division. Two sister chromatids are **identical copies**, not a homologous pair from two parents.

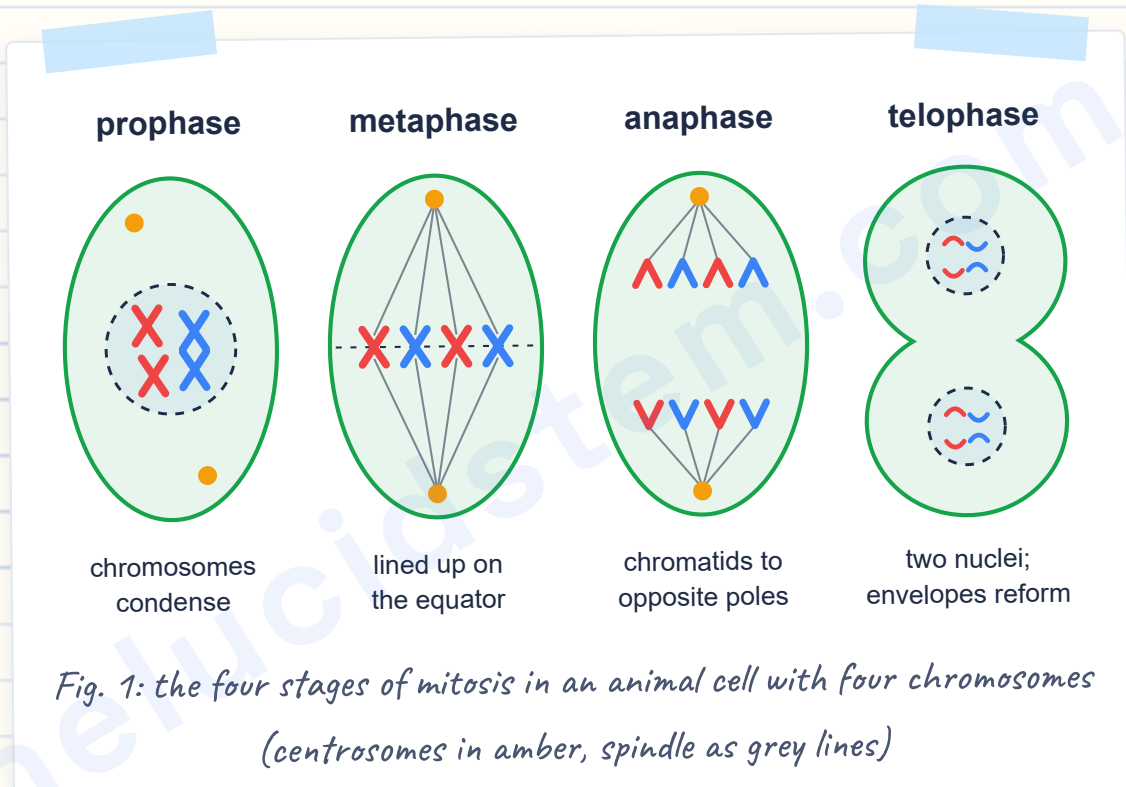
Interphase is not a resting stage. The cell is very active: it makes proteins, replicates its DNA and checks it. And DNA replication happens in **S phase of interphase**, not during mitosis; mitosis only shares out DNA that is already copied.

A tumour forms by **mitosis**, which is why the tumour cells are genetically identical to the first mutated cell. Do not say carcinogens make cells divide; they cause **mutations** in the genes that control division. Usually several mutations in one cell line are needed, which is why risk rises with age.

2 Chromosome behaviour in mitosis

Syllabus 5.2

In **prophase** the chromosomes condense and become visible as two sister chromatids, the nucleolus disappears, the spindle forms (from centrosomes in animal cells) and the nuclear envelope breaks down. In **metaphase** spindle fibres attach at the centromeres and line the chromosomes up on the **equator**. In **anaphase** the centromeres divide and the chromatids are pulled to **opposite poles**, centromere first. In **telophase** the chromatids reach the poles and uncoil, nuclear envelopes re-form and the spindle breaks down. **Cytokinesis** then divides the cell: a cleavage furrow in animal cells, a cell plate in plant cells.



Follow the chromosomes.

- ✓ **Prophase:** condense, nucleolus gone, spindle forms, envelope breaks down.
- ✓ **Metaphase:** centromeres on the equator, attached to both poles.
- ✓ **Anaphase:** centromeres divide, chromatids to opposite poles.
- Telophase:** uncoil, envelopes re-form.
- ✓ **Mitotic index** = $\text{cells in mitosis} \div \text{total cells counted}$.

Watch out!

In anaphase it is the **sister chromatids** that separate, not homologous chromosomes (that is meiosis). And the chromosome number does not halve in mitosis: a cell with 46 chromosomes gives two cells with 46 each. Count centromeres to count chromosomes.

The mitotic index counts cells in **prophase, metaphase, anaphase and telophase** only, never interphase, and divides by the **total** number of cells, not by the number in interphase. Count a large sample (at least 30, ideally more) from several fields of view.