

Mitosis and the cell cycle

Revision notes · The cell cycle and mitosis, Core Practical 6 on root tip squashes, and calculating the mitotic index.

For Pearson Edexcel International AS Biology XBI11 and International A Level Biology YBI11. **A Level only** is IA2 content (Units 4 to 6), not needed for the International AS.

Mitosis and the cell cycle Spec 3.14–3.16

The cell cycle and mitosis Spec 3.14

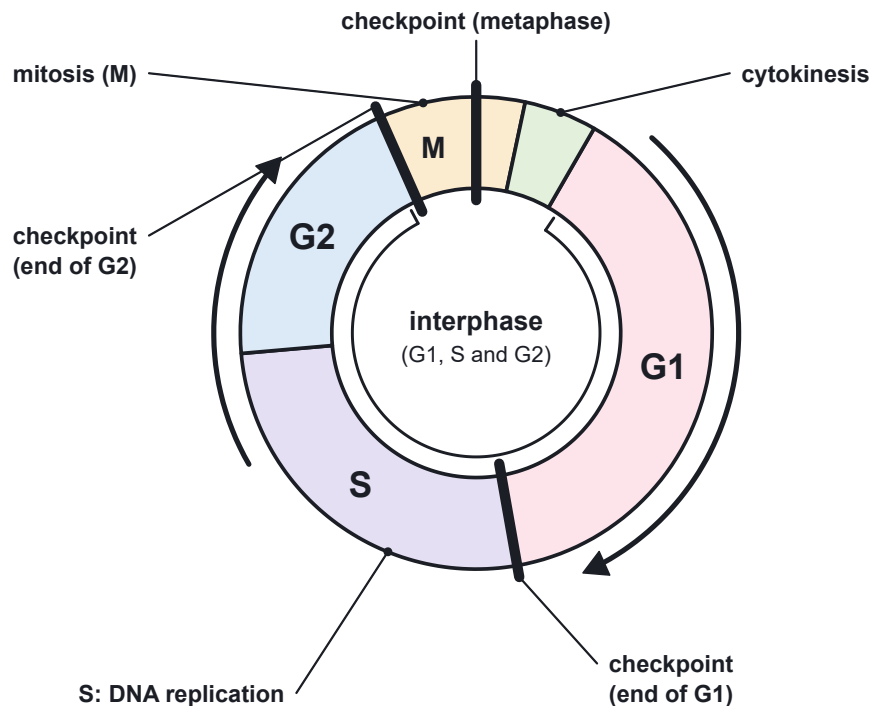
The **cell cycle** is the regular sequence of events in a dividing cell. It has two main parts: **interphase** (when the cell grows and DNA is replicated) and **mitosis** (nuclear division), followed by cytokinesis (division of the cytoplasm).

- G1: the cell grows and makes proteins and organelles.
- S phase: DNA is replicated, so each chromosome now consists of two identical sister chromatids joined at a centromere.
- G2: the cell continues to grow and prepares for division (for example by making the proteins for the spindle).

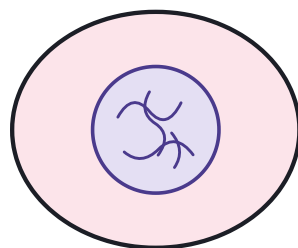
Stages of mitosis	
Stage	What happens
Prophase	Chromosomes condense and become visible as two sister chromatids joined by a centromere; the nuclear envelope breaks down; the nucleolus disappears; the spindle forms (in animal cells the centrioles move to opposite poles and organise it; plant cells have no centrioles)
Metaphase	Chromosomes line up on the equator of the cell, attached to spindle fibres by their centromeres
Anaphase	Centromeres divide; spindle fibres shorten and pull the sister chromatids (now chromosomes) to opposite poles
Telophase	Chromosomes arrive at the poles and uncoil; nuclear envelopes re-form; the nucleolus re-forms; the spindle breaks down
Cytokinesis	The cytoplasm divides, forming two daughter cells (not part of mitosis itself)

Because DNA is replicated exactly and each daughter cell receives one copy of every chromosome, mitosis produces two **genetically identical** daughter cells, with the same number of chromosomes as the parent cell. The role of mitosis in organisms includes:

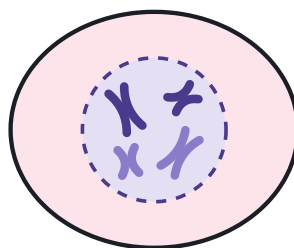
- growth of multicellular organisms, by increasing the number of cells
- replacement of damaged or worn-out cells and repair of tissues
- asexual reproduction, in which offspring are genetically identical clones of the parent, such as budding in yeast or the growth of runners and bulbs in plants



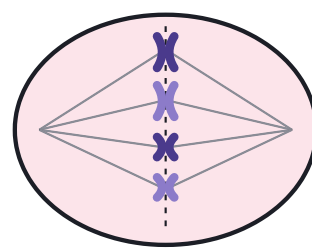
The cell cycle: **interphase** (G1, S, G2) takes most of the time, then mitosis and cytokinesis.



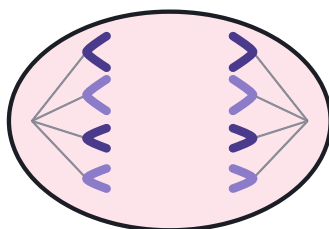
1 Interphase
cell grows; DNA replicated



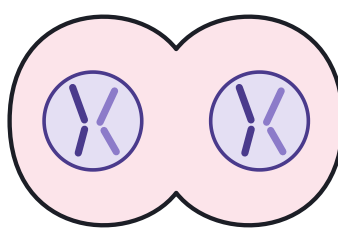
2 Prophase
chromosomes visible;
nuclear envelope breaks down



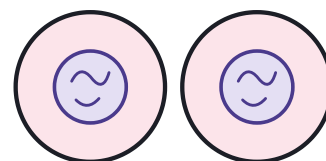
3 Metaphase
chromosomes line up on the
equator; spindle fibres attach
to the centromeres



4 Anaphase
sister chromatids pulled
to opposite poles



5 Telophase
nuclear envelopes re-form:
two nuclei



6 Cytokinesis
cytoplasm divides:
two daughter cells

Stages of mitosis: **prophase, metaphase, anaphase, telophase**, then cytokinesis.

Exam tip: In anaphase, say that the sister chromatids are pulled apart, and that the centromeres divide. Do not say that 'chromosomes' are pulled apart without saying they are chromatids at that moment.

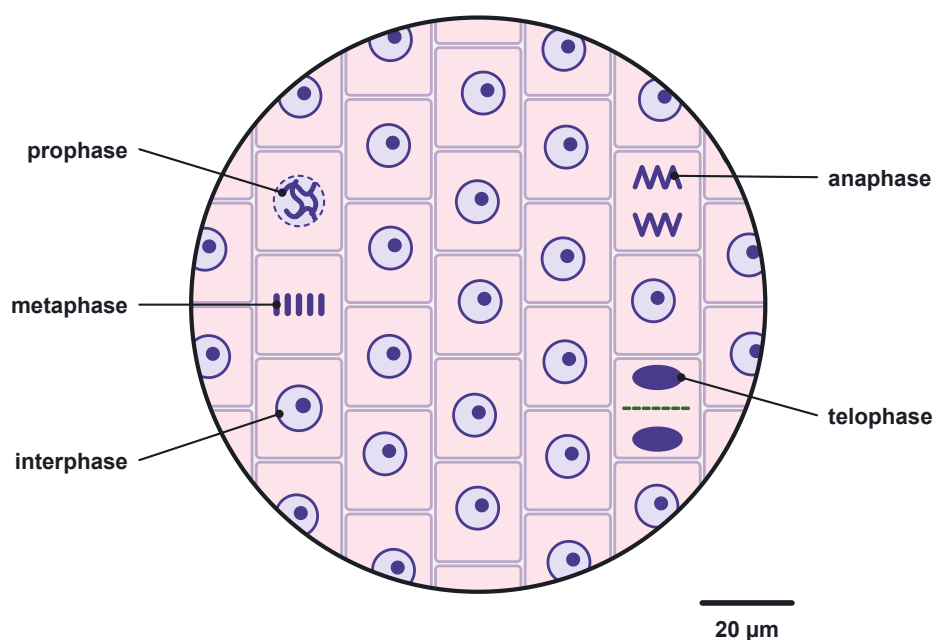
Core Practical 6: root tip squash Spec 3.15

Core practical: Core practical 6: prepare and stain a root tip squash to observe the stages of mitosis.

Root tips (for example onion, garlic or broad bean) are used because the meristem just behind the tip is the region where cells are dividing rapidly by mitosis.

1. Cut about 2 to 3 mm from the end of a growing root tip with a scalpel and place it in warm (about 60 °C) 1 M hydrochloric acid for about 5 minutes. The acid softens the tissue by breaking down the middle lamella between cells, so that the cells can be separated, and it kills the cells, fixing them in their stage.
 2. Rinse the root tip in water and place it on a clean microscope slide.
 3. Add a few drops of a stain that binds to chromosomes, such as acetic orcein, and leave for a few minutes. Spread out the tissue with a mounted needle.
 4. Lower a coverslip on at an angle. Cover it with a piece of filter paper and press down firmly with a thumb, without sliding the coverslip sideways, to squash the tissue into a thin layer of cells.
 5. View under a light microscope, starting at low power to find the region with small, square, densely stained cells, then at high power to identify the stage of each cell.
 6. Make labelled drawings of cells in each stage and count the cells in each stage in several fields of view.
- Variables to control when comparing roots: same type of plant, same length of root tip, same time in acid and stain, same temperature.
 - Risks: 1 M hydrochloric acid is an irritant, so wear eye protection; hot water baths can scald; acetic orcein stains skin and clothing and is an irritant; scalpels are sharp, so cut away from the body on a hard surface.
 - Reliability: count a large number of cells (at least several hundred) and repeat on several root tips to reduce the effects of chance.

Exam tip: Explain each step, not just the order. The squash gives a layer one cell thick, so light can pass through, and the acid separates the cells and stops further division.



In a root tip squash most cells are in interphase, because it is the longest part of the cell cycle.

Calculating the mitotic index Spec 3.16

$$\text{mitotic index} = \text{number of cells in mitosis} \div \text{total number of cells observed}$$

The mitotic index can be given as a decimal, a fraction or a percentage (multiply by 100). To find it in a root tip squash, count the cells in any stage of mitosis (prophase to telophase, where chromosomes can be seen) and the total number of cells in the same field or fields of view. Cells in interphase count only in the total.

Calculating a mitotic index

In a root tip squash, a student counted 250 cells in several fields of view. 40 of these cells were in mitosis. Calculate the mitotic index as a percentage.

1. $\text{mitotic index} = \text{number of cells in mitosis} \div \text{total number of cells}$
2. $\text{mitotic index} = 40 \div 250 = 0.16$
3. As a percentage $= 0.16 \times 100$

Answer: 16%

A tissue with a high mitotic index is growing or repairing itself, as in a root meristem. Comparing the mitotic index of different regions, or of tissues treated differently, shows where division is fastest. Counting a large number of cells in many fields of view makes the value more reliable.

Maths skill: Give a percentage if the question asks for it, and check that your count of cells in mitosis is not greater than the total.

Quick check

1. In which phase of the cell cycle is DNA replicated?
2. What happens to the chromosomes in metaphase?
3. Why are daughter cells from mitosis genetically identical?
4. Why is the root tip used for studying mitosis?
5. How is the mitotic index calculated?

Quick check answers

Mitosis and the cell cycle

- 1 . The S phase of interphase.
- 2 . They line up at the equator of the cell, attached to spindle fibres by their centromeres.
- 3 . DNA is replicated exactly in interphase and each daughter cell receives one copy of every chromosome.
- 4 . It contains meristem cells, which are dividing rapidly.
- 5 . Number of cells in mitosis divided by the total number of cells observed.