

5.2 Chromosome behaviour in mitosis

Name: _____ Class: _____ Date: _____

Total: 27 marks

KEY WORDS telophase • prophase • anaphase • metaphase
• spindle

Objective

Build the skills to answer exam questions on **chromosome behaviour in mitosis** – the four stages, the behaviour of the **spindle** and **nuclear envelope**, and identifying stages in **micrographs**.

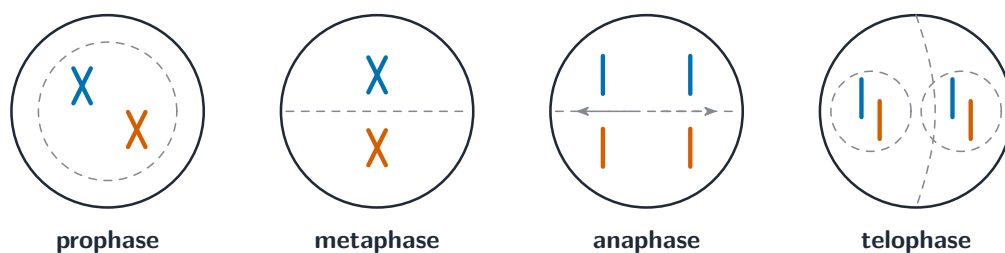
You must be able to:

- describe what chromosomes, the nuclear envelope, the membrane and the spindle do in each stage
- name and identify prophase, metaphase, anaphase and telophase from diagrams and slides
- calculate a **mitotic index**

1 Key knowledge and worked examples

■ The four stages of mitosis

stage	what happens
prophase	chromosomes coil and become visible (two chromatids); nuclear envelope breaks down; spindle forms
metaphase	chromosomes line up at the equator ; spindle fibres attach to each centromere
anaphase	centromeres split; sister chromatids are pulled to opposite poles
telophase	a set reaches each pole; a new nuclear envelope forms around each – two nuclei

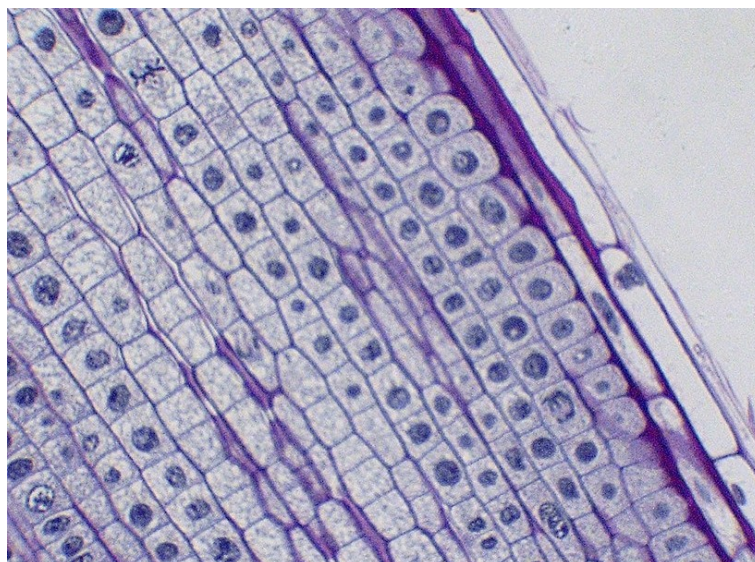


The four stages: prophase, metaphase, anaphase, telophase

Then **cytokinesis** splits the cell into two genetically identical daughter cells.

■ Identifying stages in a micrograph

Look for the clue in each cell: chromosomes lined up in the middle = metaphase; chromatids being pulled apart in a V-shape = anaphase.



An onion root tip – a growing tip catches many cells in mitosis

■ The mitotic index

The **mitotic index** is the fraction of cells that are in mitosis:

$$\text{mitotic index} = \frac{\text{number of cells in mitosis}}{\text{total number of cells}}.$$

A high index means many cells are dividing (e.g. a growing tip or a tumour).

2 Practice

2.1 Name the stage of mitosis in which: (a) chromosomes line up at the equator; (b) sister chromatids are pulled to opposite poles. [2]

2.2 State what happens to the nuclear envelope during (a) prophase and (b) telophase. [2]

3 Exam-style questions

3.1 In which stage of mitosis do the centromeres split and the chromatids move apart? [1]

- ☐ **A** anaphase
B metaphase
C prophase
D telophase

3.2 A cell is seen with its chromosomes lined up single-file across the centre of the cell. This cell is in: [1]

- ☐ **A** anaphase
B interphase
C metaphase
D telophase

3.3 A student examines a root tip and counts the cells in each stage:

stage	interphase	prophase	metaphase	anaphase	telophase
number of cells	84	9	4	2	1

(a) Calculate the mitotic index for this sample. Show your working. [2]

(b) The cells of a tumour have a much higher mitotic index than normal tissue. Explain why. [2]

3.4 Describe the behaviour of the chromosomes and the spindle during metaphase and anaphase. [4]

3.5 Four cells from a root tip were each seen in a different stage of mitosis.

- **W** chromosomes lined up singly along the equator
- **X** chromatids being pulled towards opposite poles
- **Y** chromosomes at the poles, nuclear envelopes re-forming
- **Z** chromosomes condensing and becoming visible, nuclear envelope breaking down

(a) Name the stage shown by each cell, and put the four in the correct order. [5]

(b) Describe what the spindle does in stages **W** and **X**. [3]

(c) A root tip contained 240 cells, of which 12 were in stage **X**. The whole cell cycle takes 20 hours. Estimate how long stage **X** lasts, showing your working. [3]

(d) Explain why mitosis must produce genetically identical daughter nuclei, and name **one** process in the cell cycle that ensures this. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1

(a)

- metaphase

(b)

- anaphase

2.2

(a)

- it breaks down / disappears

(b)

- it re-forms around each set of chromosomes

3.1 A

- In anaphase the centromeres split and chromatids move to opposite poles

3.2 C

- Chromosomes lined up across the centre is metaphase

3.3

(a)

- cells in mitosis = $9 + 4 + 2 + 1 = 16$; total = $84 + 16 = 100$. mitotic index = $\frac{16}{100} = 0.16$

(b)

- the tumour cells divide uncontrollably / continuously, so at any moment a larger fraction are in mitosis

3.4

- metaphase: chromosomes line up at the equator; spindle fibres attach to the centromeres; anaphase: centromeres split; sister chromatids are pulled by the spindle to opposite poles

3.5

(a)

- **Z** prophase, **W** metaphase, **X** anaphase, **Y** telophase; the order is Z, W, X, Y

(b)

- In metaphase (**W**) the spindle fibres attach to the centromere of each chromosome and pull until the chromosomes lie on the equator. In anaphase (**X**) the fibres shorten, the centromeres split, and the sister chromatids are dragged to opposite poles

(c)

- The proportion of cells seen in a stage is proportional to the time spent in it; $\frac{12}{240} = 0.05$; $0.05 \times 20 \text{ h} = 1 \text{ hour}$

(d)

- Growth, repair and asexual reproduction all need daughter cells carrying the same genes as the parent, so they work in the same way; **semi-conservative DNA replication** during interphase makes an exact copy of every chromosome before division