

5.2 Chromosome behaviour in mitosis

Name: _____ Class: _____ Date: _____ Total: 27 marks

KEY WORDS telophase 末期 • prophase 前期 • anaphase 后期 • metaphase 中期
• spindle 纺锤体

Objective

Build the skills to answer exam questions on **chromosome behaviour in mitosis** — the four stages, the behaviour of the **spindle** 纺锤体 and **nuclear envelope** 核膜, and identifying stages in **micrographs** 显微照片.

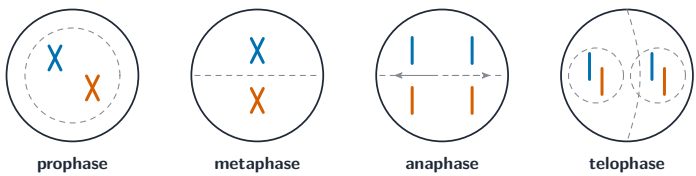
You must be able to:

- 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** 有丝分裂指数

1 Worked examples

■ The four stages of mitosis

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

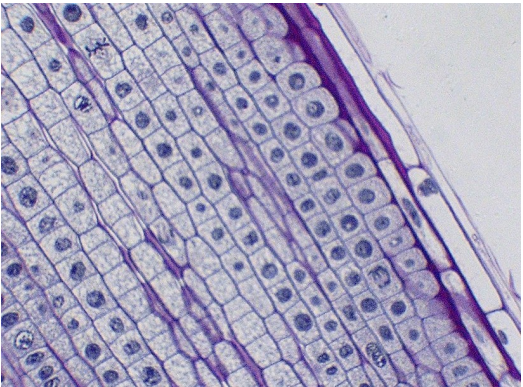


The four stages: prophase, metaphase, anaphase, telophase

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

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.