Week 14

A-Level Biology

Homework bundle for this week

本周作业合集

exercises.lol

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5. The mitotic cell cycle

Starter Quiz · 课前小测

A-Level Biology Name: _____ Score: _____

1. A chromosome is:

   ☐ a long DNA molecule wound around proteins called histones

   ☐ a single protein

   ☐ a type of carbohydrate

   ☐ a membrane

2. The two daughter cells produced by mitosis are:

   ☐ genetically identical to each other and to the parent cell

   ☐ genetically different from each other

   ☐ always specialised

   ☐ half the size forever

3. In prophase:

   ☐ chromosomes condense, the nuclear envelope breaks down, and a spindle forms

   ☐ chromosomes line up at the equator

   ☐ sister chromatids are pulled to the poles

   ☐ two new nuclei form

4. After replication, a chromosome is two identical sister _____ joined at the centromere.

   _____

5. Mitosis produces genetically identical daughter cells, which is why it is used for growth and repair.

   ☐ True ☐ False

6. In _____, the chromosomes line up along the equator of the cell.

   _____

7. During which phase of interphase is the DNA copied?

   ☐ the S phase

   ☐ the G_1 phase

   ☐ the G_2 phase

   ☐ cytokinesis

8. Select **all** the roles of mitosis.

- ☐ growth
- ☐ repair and replacement of cells
- ☐ asexual reproduction
- ☐ producing genetically varied gametes
- ☐ making ATP

Tick every correct option.

9. Anaphase is the stage where:
   - ☐ the centromeres split and sister chromatids are pulled to opposite poles
   - ☐ the spindle first forms
   - ☐ the nuclear envelope breaks down
   - ☐ the cytoplasm divides
10. Interphase (G_1, S, G_2) is the longest part of the cell cycle.

    ☐ True ☐ False

A-Level Biology

1. **a long DNA molecule wound around proteins called histones**

   Chromosomes are DNA wound tightly around histone proteins, packing a huge length into the nucleus.

2. **genetically identical to each other and to the parent cell**

   Mitosis produces genetically identical cells — they carry exactly the same genes as the parent.

3. **chromosomes condense, the nuclear envelope breaks down, and a spindle forms**

   Prophase: chromosomes coil up and become visible, the nuclear envelope breaks down, and the spindle forms.

4. **chromatids**

   Replication makes an identical copy; the two sister chromatids stay joined at the centromere until anaphase.

5. **True**

   Identical copies are exactly what growth, repair and asexual reproduction need.

6. **metaphase**

   In metaphase the chromosomes line up at the cell's equator and spindle fibres attach to each centromere.

7. **the S phase**

   DNA replication happens in the S (synthesis) phase, between G_1 and G_2.

8. **growth; repair and replacement of cells; asexual reproduction**

   Mitosis gives identical cells for growth, repair/replacement and asexual reproduction. Varied gametes come from meiosis; ATP comes from respiration.

9. **the centromeres split and sister chromatids are pulled to opposite poles**

   In anaphase the centromeres split and the spindle pulls the sister chromatids apart to the poles.

10. **True**

    Interphase takes up most of the cycle; mitosis and cytokinesis are comparatively short.

A-LEVEL BIOLOGY • EXERCISE SHEET

5.1 Replication and division of nuclei and cells

Name: _____ Class: _____ Date: _____ **Total: 12 marks**

KEY WORDS cell cycle 细胞周期 • telomere 端粒 • mitosis 有丝分裂 • mitotic cell cycle 有丝分裂细胞周期 • stem cell 干细胞

Objective

Build the skills to answer exam questions on **replication and division of nuclei and cells** — the structure of a **chromosome** 染色体, the **mitotic cell cycle** 有丝分裂细胞周期, **telomeres** 端粒, **stem cells** 干细胞 and **tumours** 肿瘤.

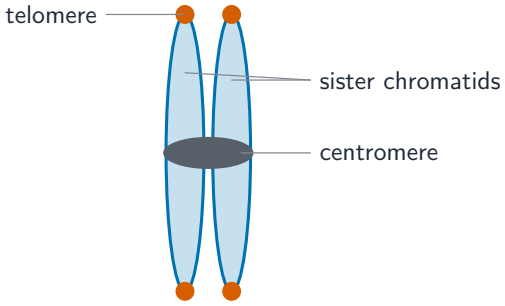
You must be able to:

- describe the structure of a chromosome (DNA, histones, sister chromatids, centromere, telomeres)
- explain the importance of mitosis and outline the cell cycle (interphase, mitosis, cytokinesis)
- outline the roles of telomeres and stem cells, and how a tumour forms

1 Worked examples

■ The structure of a chromosome

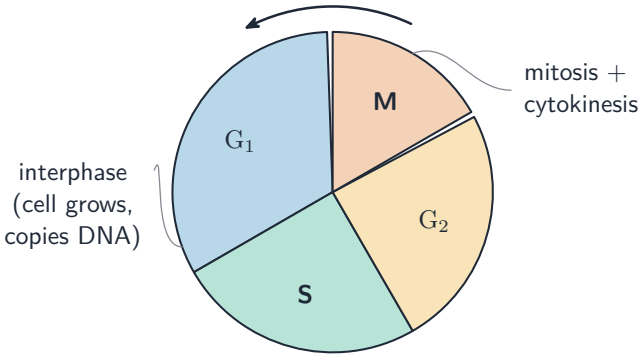
A chromosome is one long DNA molecule wound around **histone** 组蛋白 proteins. After **replication** 复制 it is two identical **sister chromatids** 姐妹染色单体 joined at the **centromere** 着丝粒, with **telomeres** capping the tips.



one chromosome = two identical copies after DNA replication

After replication: two sister chromatids joined at the centromere, telomeres at the tips

The mitotic cell cycle



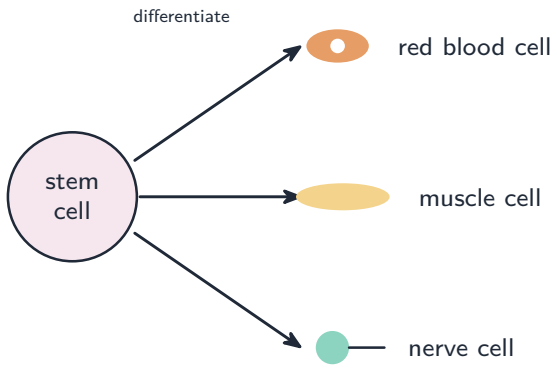
Most of the cycle is interphase (G_1, S, G_2); mitosis and cytokinesis are short

- **interphase** 间期 — growth (G_1), DNA replication (S), growth/preparation (G_2).
- **mitosis** 有丝分裂 — the nucleus divides into two **genetically identical** nuclei.
- **cytokinesis** 胞质分裂 — the cell splits into two daughter cells.

Mitosis matters for growth, replacement of dead cells, tissue repair and **asexual reproduction** 无性生殖.

Telomeres, stem cells and tumours

Telomeres carry **no genes**, so the small amount lost at each replication does not lose genes. A **stem cell** is unspecialised, keeps dividing, and can **differentiate** 分化 into specialised cells. If the control of the cycle is lost, a cell divides uncontrollably to form a **tumour**.



One stem cell can differentiate into many specialised cell types

2 Practice

2.1 Name the parts of a chromosome labelled by these descriptions: (a) where two sister chromatids are joined; (b) the protective caps at the tips. [2]

2.2 State what happens in the **S phase** of interphase. [1]

3 Exam-style questions

3.1 During which phase of the cell cycle is DNA replicated? [1]

- **A** G_1
- **B** S
- **C** G_2
- **D** mitosis

3.2 Why does the loss of a small length of telomere during replication **not** harm the cell? [1]

- **A** telomeres are made of protein
- **B** telomeres carry no genes
- **C** telomeres are replaced by histones
- **D** the lost DNA is copied later

3.3 Explain why mitosis produces two genetically identical daughter cells, and give **two** situations where this is important. [3]

3.4 (a) State what is meant by a stem cell. [2]

(b) Explain how the loss of control of the cell cycle can lead to a tumour. [2]

Solutions

2.1 (a) centromere; (b) telomeres.

2.2 the DNA is replicated / copied.

3.1 B. DNA is replicated in the S phase.

3.2 B. Telomeres carry no genes, so losing a little does not lose genes.

3.3 mitosis copies the DNA exactly (S phase) and separates identical sister chromatids, so each daughter gets an identical set of genes; any two of: growth / replacement of dead cells / tissue repair / asexual reproduction.

3.4 (a) an unspecialised cell that can keep dividing and can differentiate into specialised cells.
(b) the cell divides repeatedly without stopping, forming an uncontrolled mass of cells — a tumour.

20 Telomeres become shorter during each cell cycle of a specialised cell.

In which phase of the cell cycle do telomeres shorten?

A cytokinesis

B G_1

C S

D G_2

21 Telomeres prevent the loss of genes during DNA replication.

Which row correctly shows cell types that contain telomeres?

	typical animal cell	typical plant cell	typical bacterial cell
A	✓	✓	✓
B	✓	✓	✗
C	✗	✗	✓
D	✓	✗	✗

key

✓ = present

✗ = **not** present

21 What are roles of adult stem cells in humans?

1 repair other cells by mitosis

2 divide to replace cells in tissues

3 differentiate into a new organism

A 1 and 3 **B** 1 only **C** 2 and 3 **D** 2 only

22 Which statements are correct for the mitotic cell cycle?

1 DNA is replicated semi-conservatively during mitosis.

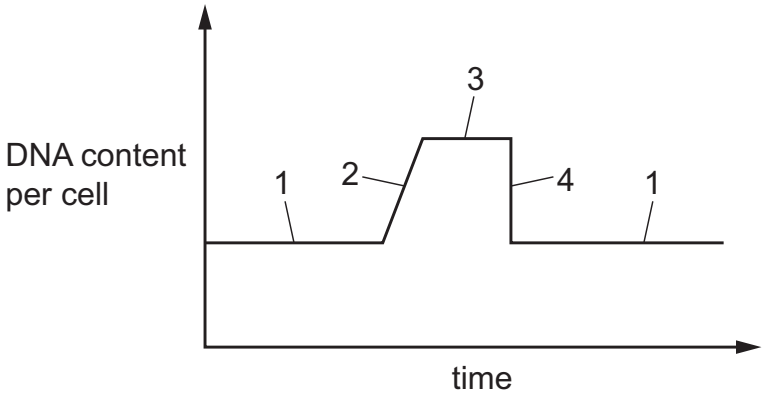
2 DNA is never changed from one generation of cells to the next generation.

3 The daughter cells at the end of a mitotic cell division have the potential to produce the same enzymes as the parent cell.

4 The same quantity of DNA is distributed to the nuclei of two new cells at the end of a mitotic cell division.

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

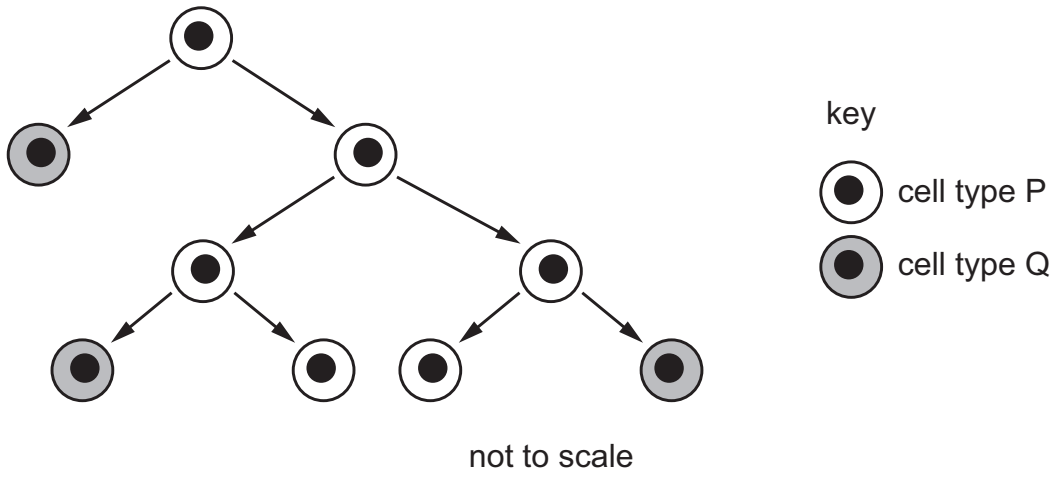
19 The DNA content of a cell changes as the mitotic cell cycle proceeds through a series of stages.



Which row correctly identifies when DNA replicates and when the nuclear envelope breaks down?

	DNA replicates	nuclear envelope breaks down
A	1	3
B	1	4
C	2	3
D	2	4

20 The diagram shows three cycles of cell division from an original cell of cell type P in bone marrow. Some of the cells that form are cell type Q.



not to scale

Which row correctly identifies cell type P and cell type Q?

	cell type P	cell type Q
A	cancer cell	differentiated cell
B	cancer cell	stem cell
C	differentiated cell	stem cell
D	stem cell	differentiated cell

A-LEVEL BIOLOGY • EXERCISE SHEET

5.2 Chromosome behaviour in mitosis

Name: _____ Class: _____ Date: _____ **Total: 14 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.

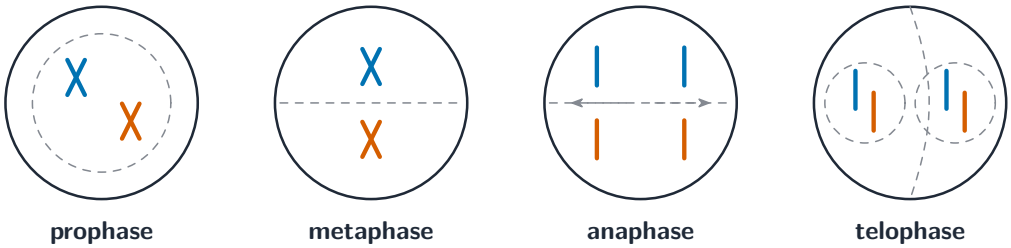
You must be able to:

- 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

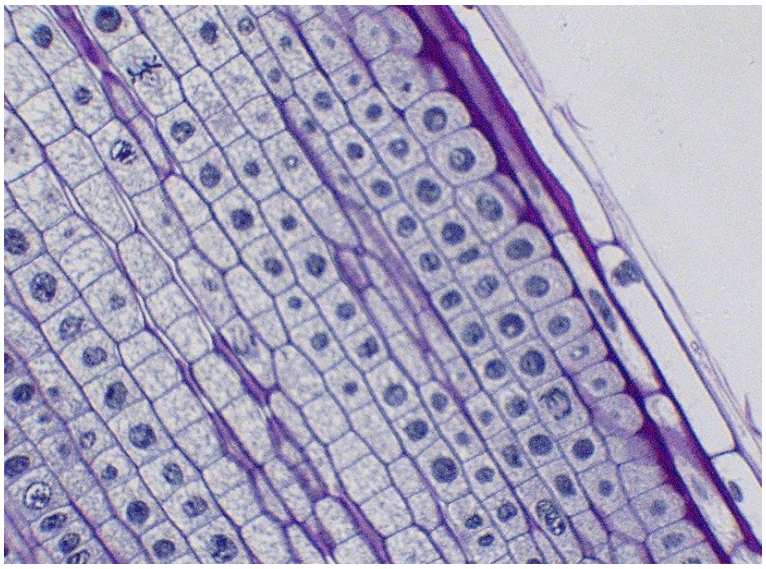


The four stages: prophase, metaphase, anaphase, telophase

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]

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 $= \dfrac{16}{100} = 0.16$.
(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.

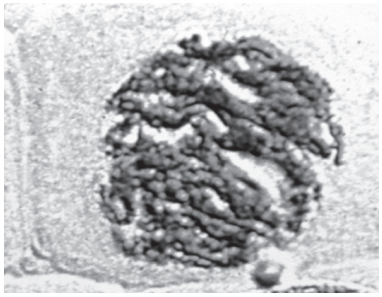
19 A human muscle cell contains 46 chromosomes.

How many centromeres will be present in a cell during the stages of the mitotic cell cycle?

	early prophase	metaphase	anaphase
A	46	46	92
B	46	92	92
C	46	46	46
D	92	46	46

21 The photomicrographs show stages of mitosis.

1



2

3

4

5

What is the correct order for the stages of mitosis?

A 2 → 3 → 5 → 1 → 4

B 2 → 4 → 1 → 5 → 3

C 3 → 2 → 5 → 4 → 1

D 5 → 1 → 4 → 3 → 2

22 Which events listed are part of mitosis?

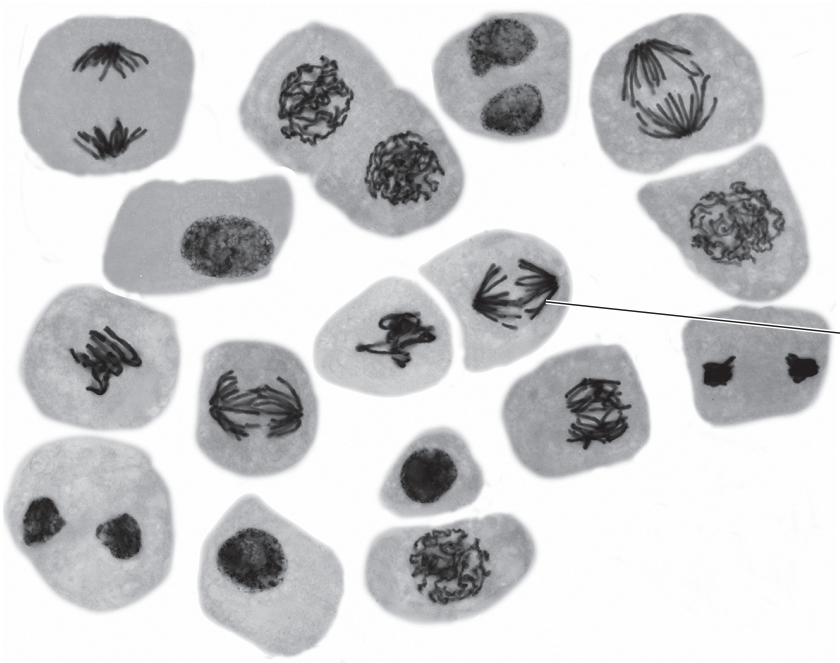
1 interphase

2 prophase

3 cytokinesis

A 1, 2 and 3 **B** 1 and 2 only **C** 1 only **D** 2 only

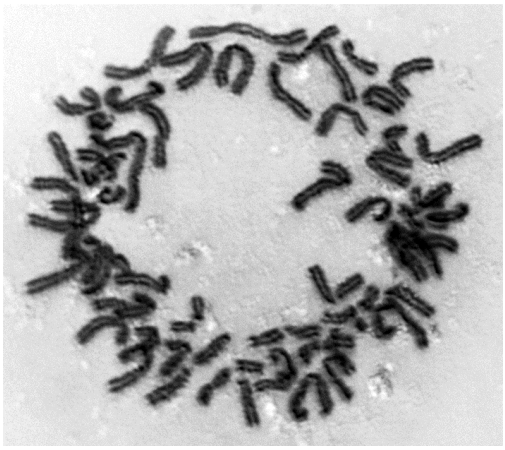
23 The photomicrograph shows 17 cells in different stages of the mitotic cell cycle.



Which row is correct for this photomicrograph?

	the role of a centromere in cell 1	the proportion of the cells in the photomicrograph in telophase
A	attaches daughter chromosomes to spindle fibres	> 0.2
B	holds sister chromatids together	> 0.2
C	attaches daughter chromosomes to spindle fibres	< 0.2
D	holds sister chromatids together	< 0.2

23 The photomicrograph shows a stage of the cell cycle.



Which stage is shown in the photomicrograph?

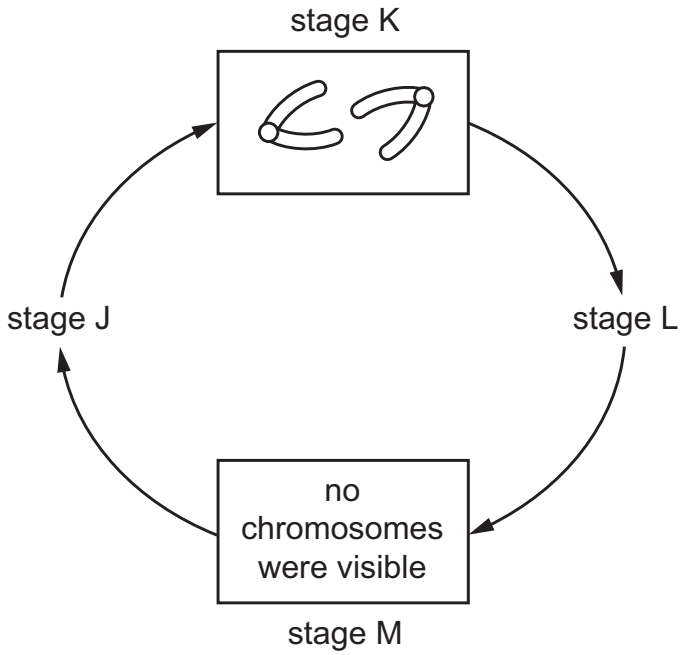
A anaphase

B interphase

C metaphase

D telophase

21 A student made a drawing of two chromosomes at stage K of a mitotic cell cycle.



Which row shows the possible events that occur in stages J, L and M?

	J	L	M
A	spindle attachment	cytokinesis	DNA replication
B	chromosome condensation	spindle attachment	cytokinesis
C	DNA replication	chromosome condensation	spindle attachment
D	cytokinesis	DNA replication	chromosome condensation

1 The wall of the small intestine is highly folded to form villi. Between the villi are infoldings known as crypts of Lieberkühn.

Fig. 1.1 is a diagram of a section through a single villus and a crypt of Lieberkühn.

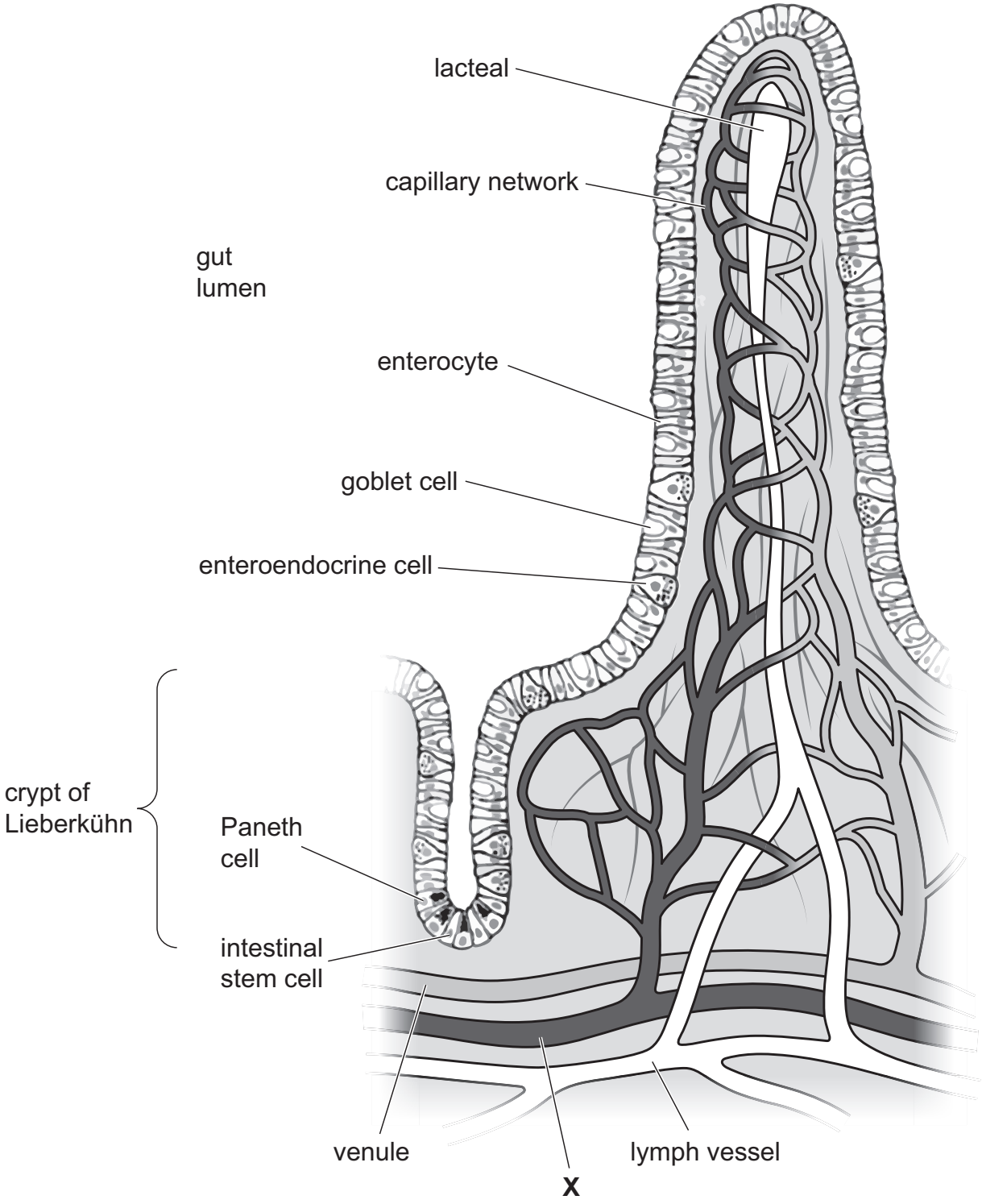


Fig. 1.1

Fig. 1.1 shows that the epithelium of the villus contains mainly goblet cells and cells known as enterocytes. Both cell types have microvilli on the apical surface (surface facing the gut lumen).

Goblet cells are involved in the production of mucus.

Enterocytes are adapted for the absorption of the soluble products of digestion. These products enter the circulatory system.

(a) A student incorrectly stated that an enterocyte has many **cilia** on its apical surface.

Explain the difference between a cilium and a microvillus.

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..... [2]

(b) Suggest **one** role of the mucus produced by the goblet cells of the villus.

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..... [1]

(c) In Fig. 1.1, blood vessel **X** delivers blood to the capillary network of the villus, where tissue fluid is formed. Some of the fluid passes back into the capillaries and then into the venule.

(i) Blood vessel **X** receives blood from an artery.

Name the type of blood vessel represented by **X**.

..... [1]

(ii) Describe the formation of tissue fluid in the capillary network of the villus.

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..... [2]

(d) In response to the presence of compounds in the gut lumen, enteroendocrine cells synthesise and release peptides (short chains of amino acids) that are cell-signalling molecules. One of these cell-signalling molecules is known as GLP-1.

GLP-1 initiates a number of responses in different body cells. Some of these responses include:

- the increase in release of the hormone insulin from cells in the pancreas
- the decrease in release of acid from cells in the stomach.

Outline, **in sequence**, the main stages involved in the process of cell signalling by GLP-1.

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..... [3]

(e) Paneth cells, which are secretory cells, are located between intestinal stem cells at the base of the crypt of Lieberkühn, as shown in Fig. 1.1.

A Paneth cell has a very different appearance to an intestinal stem cell.

Fig. 1.2 is a transmission electron micrograph of a Paneth cell.

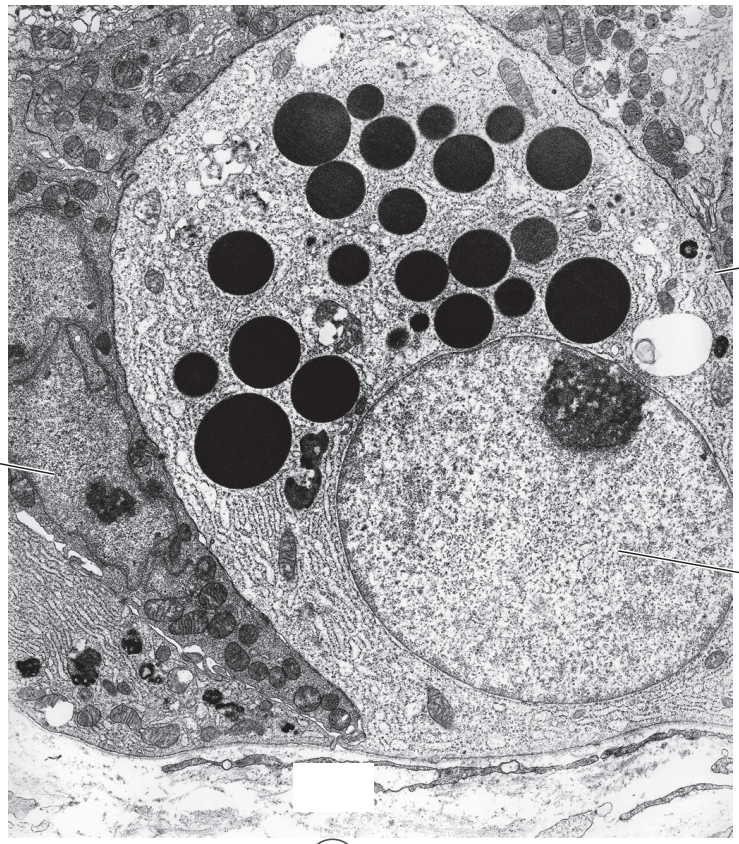

Fig. 1.2

(i) Paneth cells are formed following the mitotic division of an intestinal stem cell during a cell cycle.

Complete the cell cycle shown in Fig. 1.3 by naming, **in sequence**, the stages of mitosis.

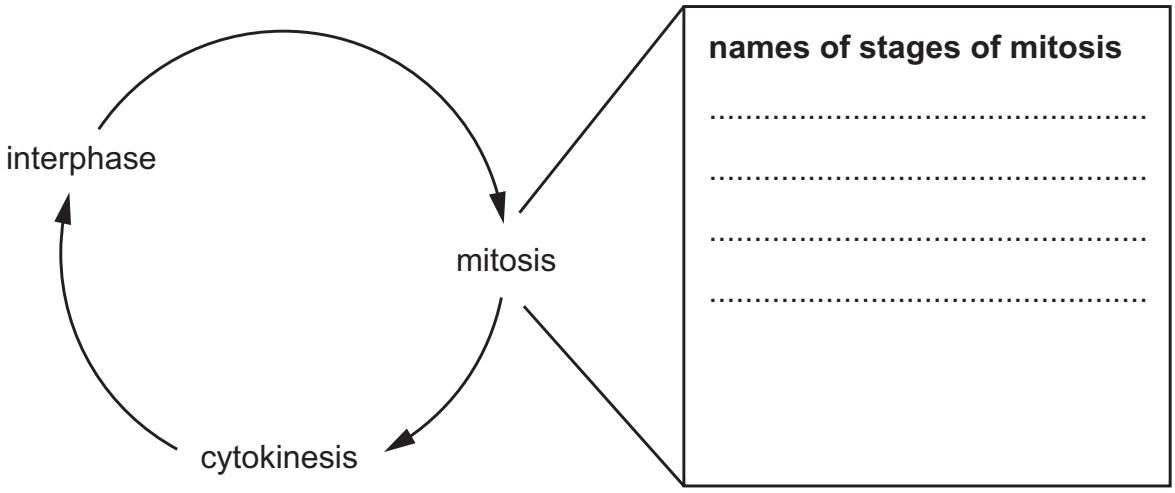

Fig. 1.3

[1]

(ii) One of the functions of a Paneth cell is to synthesise and secrete peptides and proteins that act against pathogens in the gut lumen.

State **and** explain the evidence, **visible in Fig. 1.2**, which suggests that a Paneth cell:

- is a secretory cell
- synthesises many peptides and proteins.

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..... [3]

(iii) Explain why a Paneth cell has a very different appearance to an intestinal stem cell.

.....

.....

..... [1]

[Total: 14]