A-Level Biology

Mitosis and the Cell Cycle

Question Paper

Time available: 75 minutes
Marks available: 58 marks

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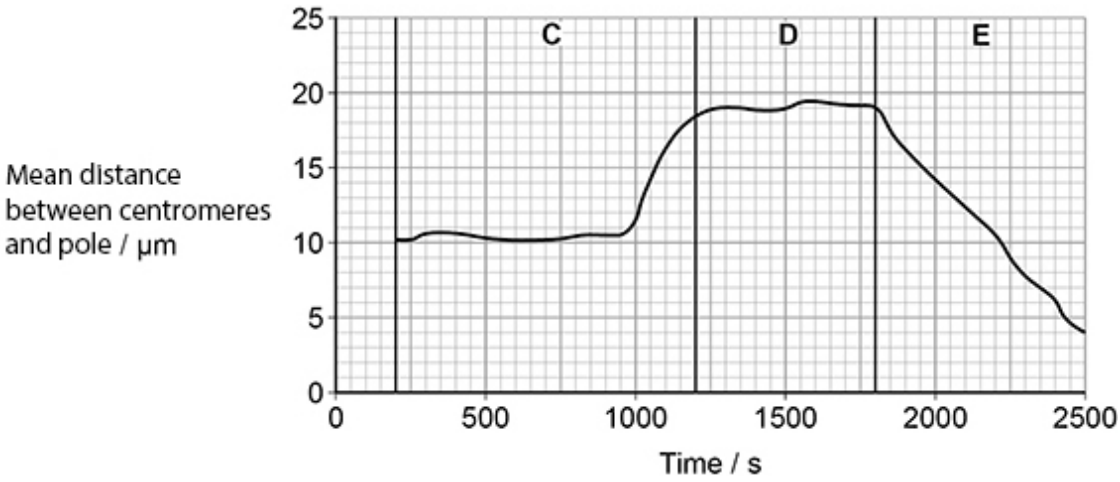
1. (a) The figure below shows the mean distance between centromeres and the poles (ends) of the spindle during mitosis.



Calculate the rate of movement of the centromeres during phase **E**.

Give your answer in µm minute^{-1} **and** to 3 decimal places.

_____ µm minute^{-1}

(2)

(b) Name the three phases of mitosis shown by **C**, **D** and **E** on the figure above.

Describe the role of the spindle fibres and the behaviour of the chromosomes during each of these phases.

C _____

D _____

E _____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

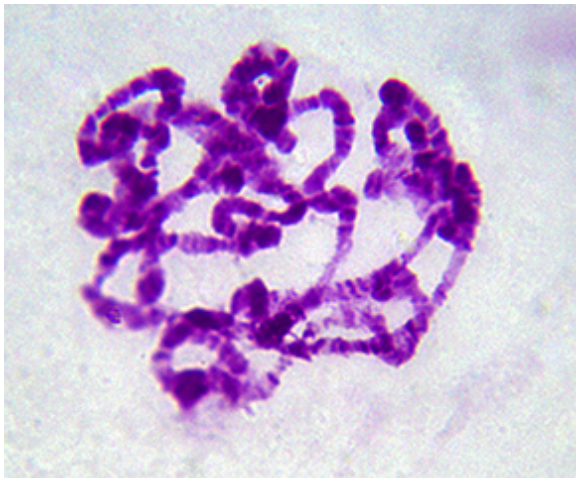
_____

(5)

(Total 7 marks)

2. This question is about mitosis in cells.

The image below shows the arrangement of the genetic material in a cell during prophase.



(a) Describe and explain the arrangement of the genetic material shown in the above image.

_____

_____

_____

_____

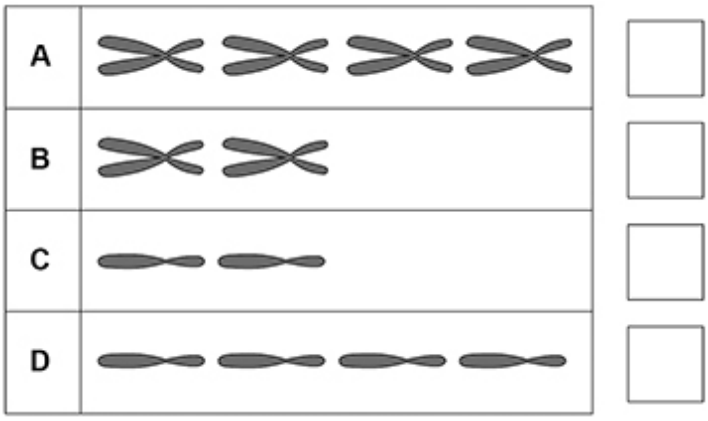
_____

_____

(2)

(b) The diploid number of chromosomes in the body cell of an insect species is four.

Tick (✓) the box next to the diagram **A**, **B**, **C** or **D** that represents the appearance of chromosomes in a cell during metaphase in this species.



(1)

(c) Name the fixed position occupied by a gene on a DNA molecule.

_____

(1)

(d) Describe how a gene is a code for the production of a polypeptide. Do **not** include information about transcription or translation in your answer.

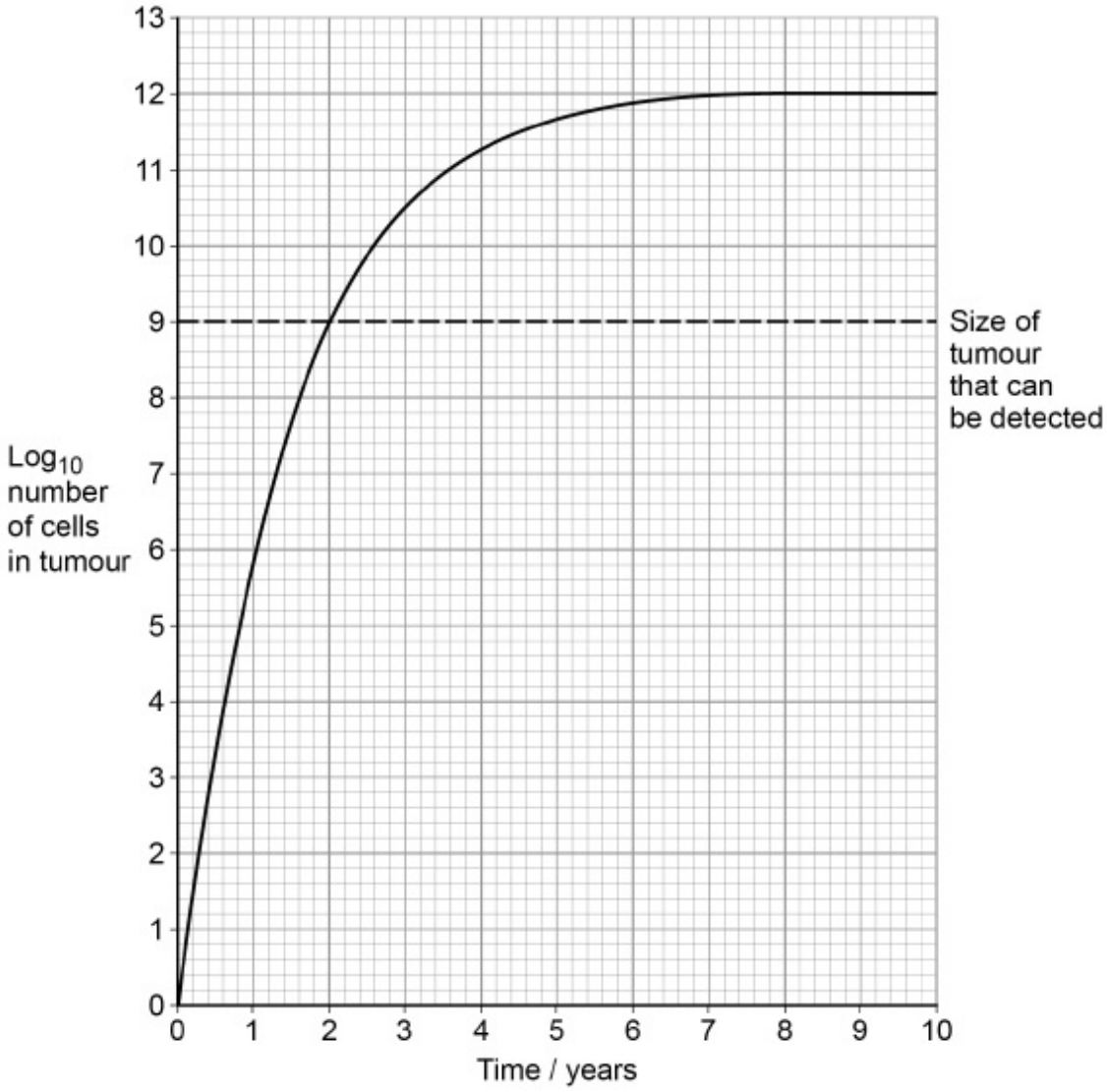
(3)

(Total 7 marks)

3. Uncontrolled cell division can cause tumours to form.

Figure 1 shows the growth pattern followed by a type of tumour.

Figure 1



(a) Use **Figure 1** to calculate the percentage of maximum growth this type of tumour reaches before it can be detected.

You will need to use the 10^x button on your calculator.

Answer = _____%

(1)

(b) **Figure 1** can also be used to calculate the age of this type of tumour.

At diagnosis, a patient had a tumour of 3.98×10^{11} cells.
Calculate the age of the tumour.

You will need to use the $\log_{10}$ button on your calculator.

Answer = _____ years

(1)

Trexall is a drug that can be used to slow the development of various forms of cancer.

Trexall slows cell division by interacting with an enzyme called dihydrofolate reductase (DR).

DR is involved in making nucleotides; the substrate for DR is folic acid.

Figure 2 shows the chemical structure of Trexall.

Figure 3 shows the chemical structure of folic acid.

Figure 2

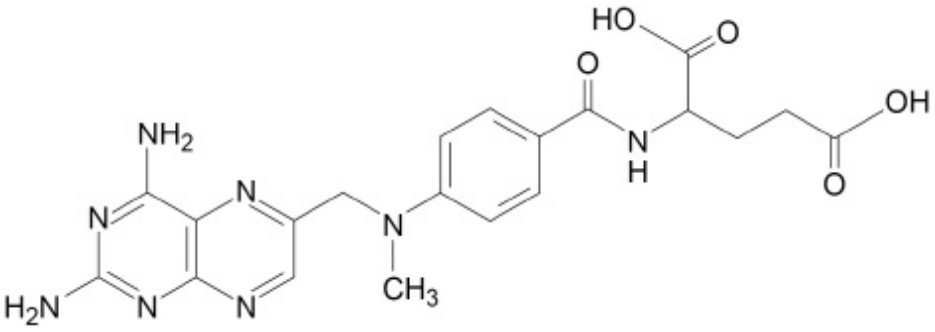
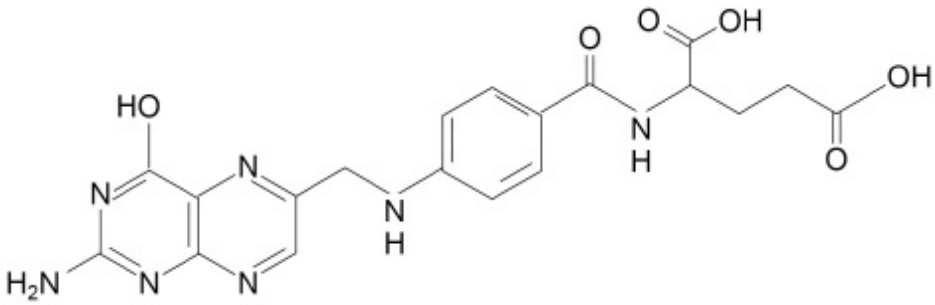


Figure 3



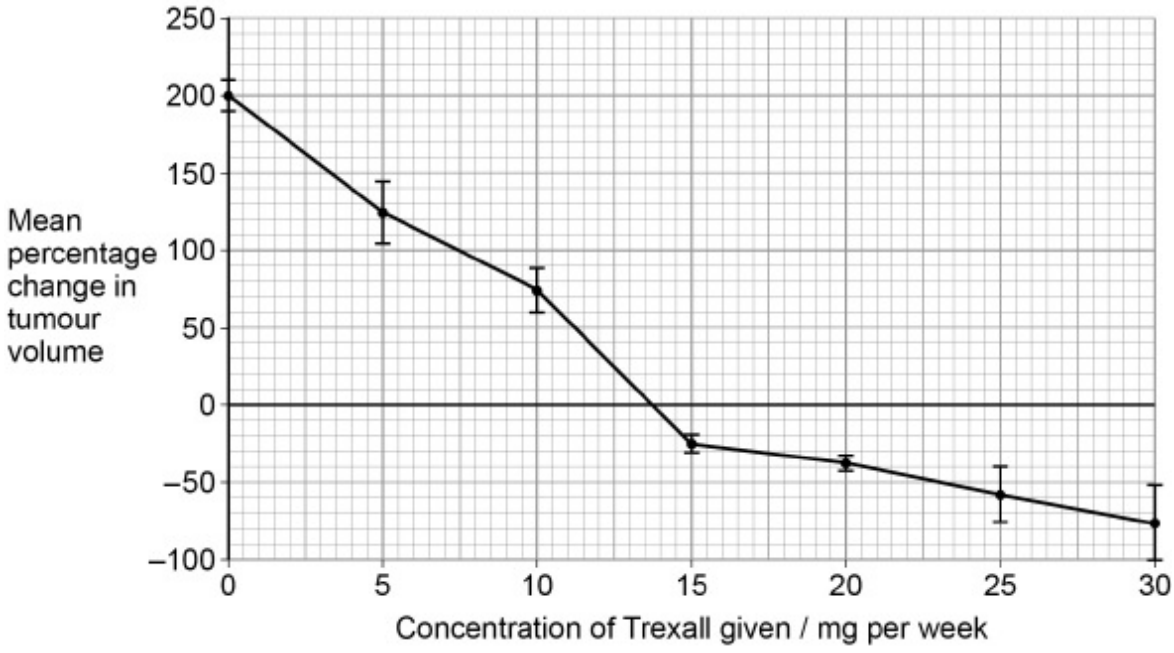
(c) Use the information provided to suggest how Trexall slows cell division.

(3)

Doctors investigated how the concentration of Trexall given to patients affected the growth of lung tumours. The doctors measured the volume of tumours at the beginning of the study and after 8 months.

Figure 4 shows the results of this investigation. The bars represent ± 2 standard deviations. A value of ± 2 standard deviations from the mean includes over 95% of the data.

Figure 4



(d) The scientists measured the percentage change in tumour volume.

Suggest why they recorded both percentage change **and** tumour volume.

Percentage change _____

_____

_____

_____

Tumour volume _____

_____

_____

_____

(2)

(e) A lung cancer patient received 15 mg of Trexall per week. After treatment, the diameter of his lung tumour was 35.8 mm

Assuming the tumour was spherical, use the mean percentage change in tumour volume shown in **Figure 4** to calculate the volume of the patient's tumour before **treatment** with Trexall.

The formula for the volume of a sphere is $\frac{4}{3}\pi r^3$ where $\pi = 3.14$

Answer = _____ mm^3

(2)

(f) To reduce the size of tumours, would it be better to use 30 mg of Trexall per week, or 20 mg of Trexall per week?

Explain your answer.

(2)

Trexall can also be used to slow the development of rheumatoid arthritis (a pain-causing joint disease).

Scientists investigated the effectiveness of Trexall as a pain relief treatment in 12 rheumatoid arthritis patients. All of the patients were female. They randomly divided the patients into two groups:

- Group **R** received Trexall tablets for 35 days
- Group **S** was a control group.

They asked both groups to rate their pain on a scale of 0–10 (0 being no pain and 10 being the worst pain possible) at the start and then every 7 days for 35 days. They calculated mean scores for each group.

Their results can be seen in the table.

Number of days of treatment	**Mean score for severity of pain (scale 0–10)**	
	Group R	**Group S**
0	9.7	9.8
7	8.2	9.1
14	8.4	8.6
21	7.6	7.2
28	6.3	7.5
35	5.1	7.8

(g) Apart from age and general health, give **two** important factors when choosing patients for this investigation.

1 _____

2 _____

(1)

(h) A student analysed the table above and concluded that Trexall was effective in reducing pain in arthritis patients.

Evaluate the student's conclusion.

(3)

(Total 15 marks)

4. (a) Mitosis is important in the life of an organism. Give **two** reasons why.

(2)

A biologist used a microscope to investigate plant tissue where some of the cells were dividing by mitosis. She examined 200 cells and counted the number of cells in interphase and in each stage of mitosis.

The table shows some of the cells she saw, and the percentage of cells in interphase and in two stages of mitosis, **A** and **B**.

Stage of cell cycle	Percentage of cells
Interphase 	90
Stage **A** 	3
Stage **B** 	1

Images by Edmund Beecher Wilson [Public domain], via Wikimedia Commons

(b) (i) Explain why the biologist chose to examine 200 cells.

_____

_____

_____

(1)

(ii) Name Stage **A** and Stage **B**. Give the evidence from the photograph that you used to identify the stage.

Name of Stage **A**_____

Evidence _____

_____

Name of Stage **B**_____

Evidence _____

_____

(4)

(c) In this tissue one complete cell cycle took 20 hours.
Using information from the table, calculate the mean time for these cells to complete mitosis. Show your working.

Answer _____

(2)

(Total 9 marks)

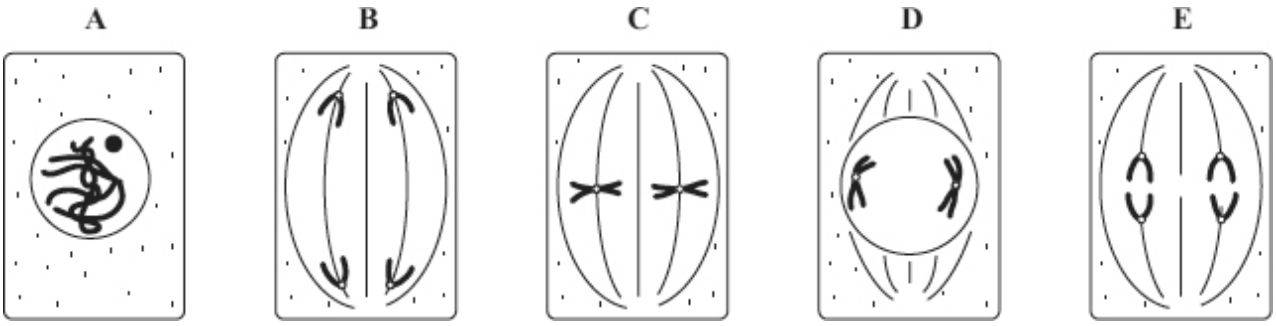
5.

(a) In which phase of the cell cycle does DNA replication take place?

_____

(1)

(b) The diagrams show five stages of mitosis.



List the stages **A** to **E** in the correct sequence, beginning with the earliest stage.

_____ _____ _____ _____ _____

(1)

(c) Describe the role of the spindle during mitosis.

_____

_____

_____

_____

(2)

(d) Meiosis also occurs during the life cycle of organisms. What is the importance of meiosis?

_____

_____

_____

_____

(2)

(Total 6 marks)

6. (a) The following statements describe stages of mitosis.

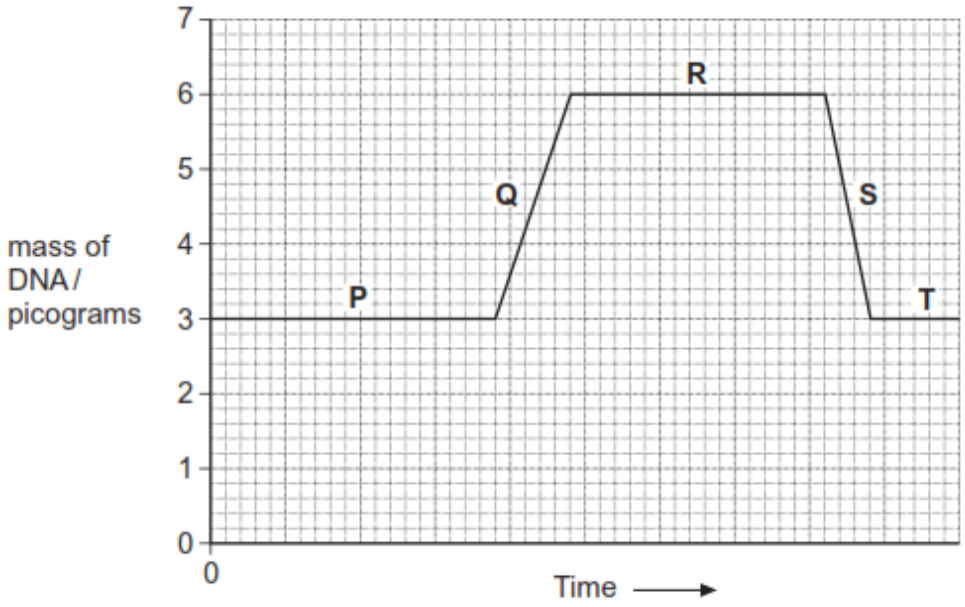
A chromosomes align at the centre of the cell attached to spindle fibres
B chromatids are in groups at the poles
C chromosomes become visible
D chromatids move towards the poles

Complete the table by entering the appropriate letter.

Stage of mitosis	Letter of description of the stage
Prophase	
Metaphase	
Anaphase	
Telophase	

(3)

(b) The graph shows changes in the mass of DNA in a cell during one cell cycle. Five stages have been identified on the graph.



(i) Which letter represents the stage when DNA is replicating? ☐

(1)

(ii) Explain the change in the DNA content during stage **S**.

_____

_____

(1)

(Total 5 marks)

7. A student prepared a stained squash of cells from the root tips of garlic to calculate a mitotic index. He:

1. cut the end 5 mm from 10 garlic roots
2. placed the root tips into a Petri dish containing 5 cm^3 of hydrochloric acid for 12 minutes
3. rinsed the root tips in distilled water
4. placed one of the root tips on a microscope slide and added toluidine blue stain
5. placed a coverslip onto the microscope slide, and gently pressed the coverslip downwards on the root tip
6. observed the root tip using an optical microscope.

(a) Suggest why the student soaked the root tips in hydrochloric acid in step **2**.

(2)

(b) Pressing the coverslip downwards enabled the student to observe the stages of mitosis clearly.

Explain why.

(2)

The diagram below shows the student's drawing of one field of view.

(c) Name the stage of mitosis shown in cell **G**. Explain the appearance of this cell.

Stage of mitosis _____

Explanation _____

_____

_____

_____

_____

(2)

(d) Use the diagram above to calculate a mitotic index for the cells in this field of view.

Mitotic index _____

(1)

(e) Other students in the class followed the same method, but calculated different mitotic indices.

Apart from student errors, suggest **two** explanations why.

1 _____

_____

_____

2 _____

_____

_____

(2)

(Total 9 marks)