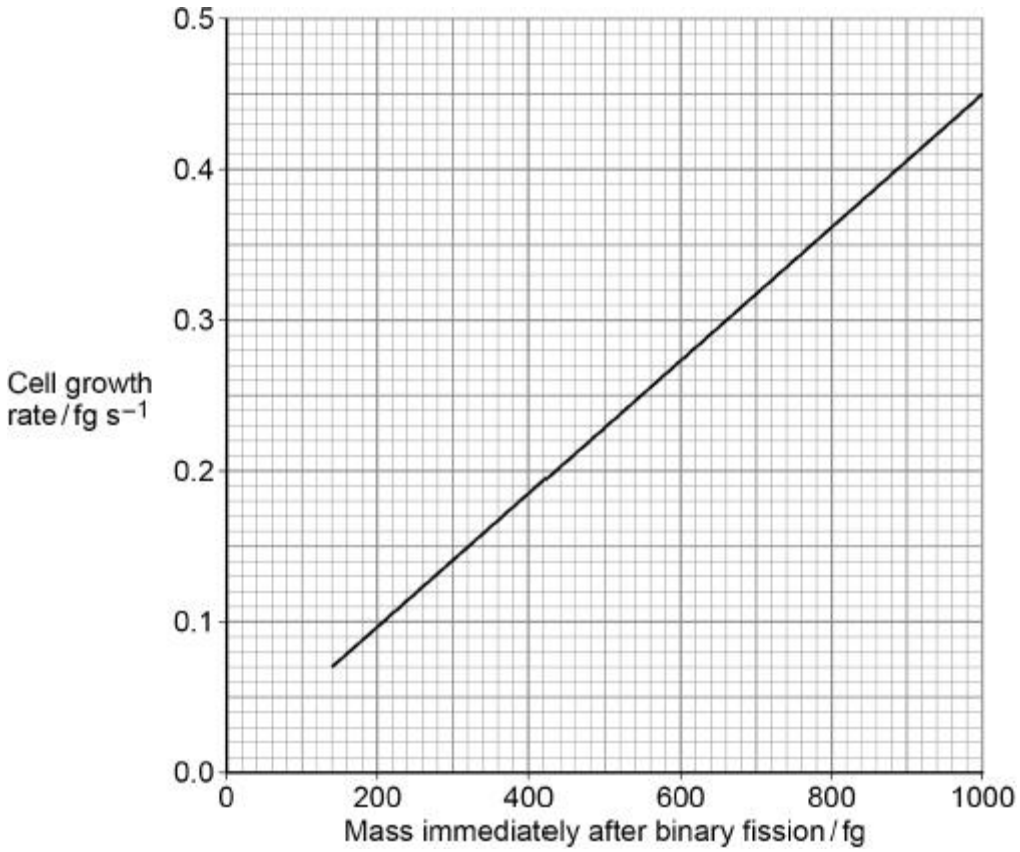
Q1.

(a) Describe binary fission in bacteria.

(3)

The cell growth rate of the bacterium *Bacillus subtilis* is proportional to its mass immediately after binary fission.

The graph below shows this relationship.



(b) The mass of the bacterial cells was measured in femtograms (fg).

1 fg (femtogram) = 1×10^{-15} g

Place a tick (✓) in the box next to the number that is equal to 680 fg

0.000 000 000 006 8 g	☐
6.8×10^{-13} g	☐
6.8×10^{-15} g	☐
6.8×10^{-17} g	☐

(1)

A scientist determined the growth rate of a *B. subtilis* cell by measuring its mass for 5 minutes.

In those 5 minutes, the cell's mass increased by 90 fg

(c) Use this information and the graph above to determine the mass of this cell immediately after binary fission.

Show your working.

Answer _____ fg

(2)

(d) Suggest and explain how **two** environmental variables could be changed to increase the growth rate of these cells.

Suggestion 1 _____

_____

_____

Explanation _____

_____

_____

Suggestion 2 _____

_____

_____

Explanation _____

_____

_____

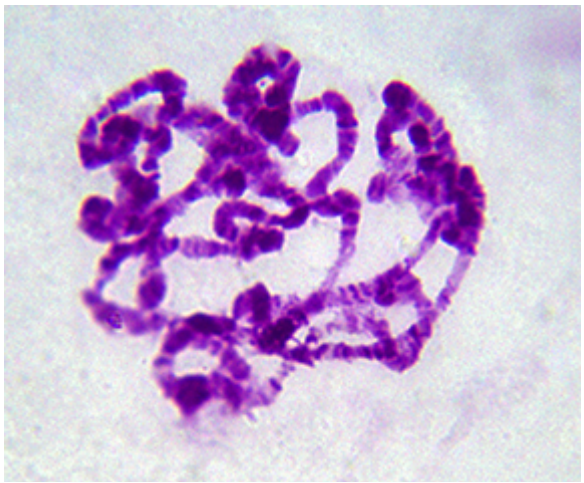
(4)

(Total 10 marks)

Q2.

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.

_____

_____

_____

_____

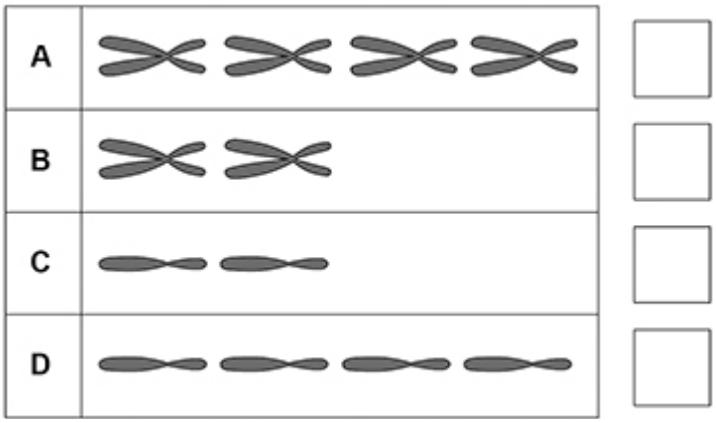
_____

_____

(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)

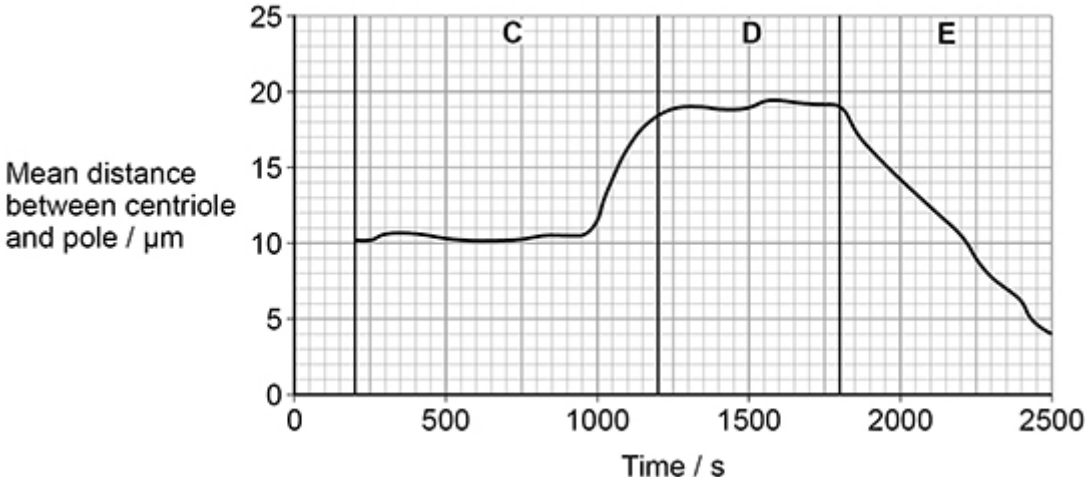
(c) Name the fixed position occupied by a gene on a DNA molecule.

_____

(1)

Q3.

(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 _____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

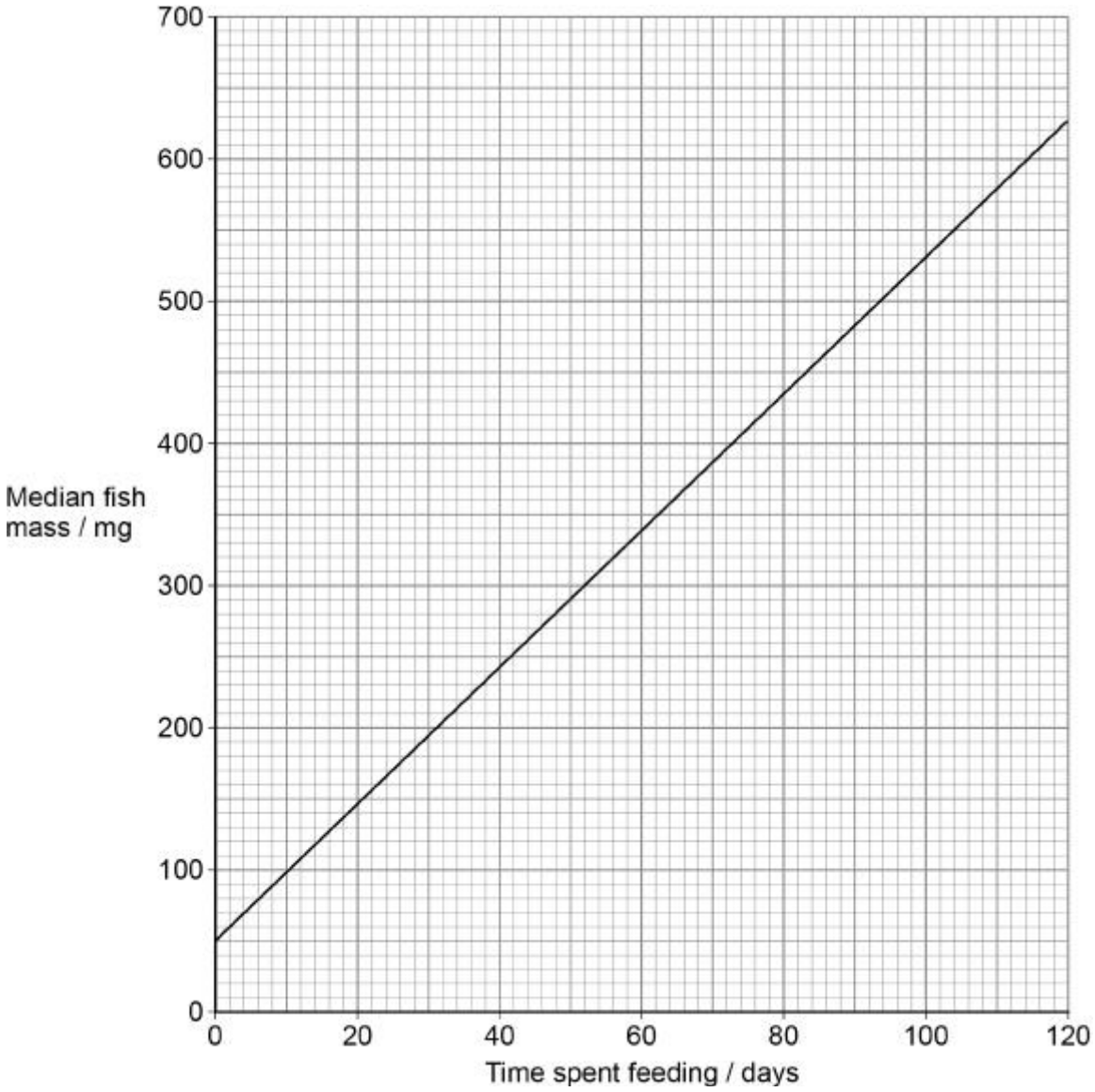
(5)

(Total 7 marks)

Q4.

Trout is a type of fish, often produced commercially in trout farms.

A scientist investigated the growth of farmed trout. She determined the median mass of a large population of trout at intervals. She started measuring on the day the newly hatched fish began feeding. Her results are shown on the graph below.



The best fit line shown on the graph is represented using this equation.

median fish mass = (m × days feeding) + 50

where m is the gradient of the best fit line.

(a) Use the graph above and the equation to calculate the median mass of fish after 195 days' feeding.

Show your working.

Answer _____ mg

(2)

(b) A trout body cell contains 80 chromosomes.

The table below shows the number of chromosomes and the mass of DNA in different nuclei. All the nuclei are from the same trout.

Complete the table below.

Nucleus	Number of chromosomes	Mass of DNA / arbitrary units
At prophase of mitosis	80	
At telophase of mitosis		25
From an egg cell		

(2)

(c) Give **one** reason why trout eggs produced by meiosis are genetically different.

_____

_____

_____

(1)

A trout body cell contains 80 chromosomes.

Farmed female trout are treated so that they produce diploid egg cells.

(d) Give the number of chromosomes in body cells of the offspring produced from treated farmed female trout and untreated farmed male trout.

Number of chromosomes _____

(1)

(e) The offspring produced from farmed trout are sterile. Suggest and explain why.

_____

_____

_____

_____

_____

_____

(2)

(Total 8 marks)

Q5.

Read the following passage.

In laboratory tests, scientists investigated the effects of a new drug called ABZ on stomach tumour cells. They found ABZ stopped mitosis by preventing the formation of spindle fibres. They also found that ABZ affected some healthy cells.

Mitosis is a controlled process. Cyclin B is a protein found in a cell's nucleus. It regulates the timing of mitosis during the cell cycle. Mitosis starts when the concentration of Cyclin B in the nucleus rises sharply and ends when it falls. The scientists found that ABZ increased, and maintained, a high concentration of Cyclin B in stomach tumour cells.

Programmed cell death is called apoptosis. Two nuclear proteins, Bcl-2 and Bax, are involved in controlling apoptosis. Apoptosis is prevented when the ratio of Bcl-2 to Bax is high and is promoted when this ratio is low. The scientists found that ABZ decreased the concentration of Bcl-2 and increased the concentration of Bax in stomach tumour cells.

From their results the scientists claimed that ABZ could be used for the successful treatment of stomach cancer.

Use information from the passage and your own understanding to answer the questions.

(a) Suggest why preventing the formation of spindle fibres (lines 2–3) stopped the cell cycle.

_____

_____

_____

_____

_____

_____

(2)

(b) Suggest and explain why ABZ could be used as a treatment for cancer even though it affects some healthy cells (lines 3–4).

_____

_____

_____

_____

(1)

Q6.

Scientists investigated the cell cycle in heart cells taken from mice 6 days before their birth and then at 4, 14 and 21 days after their birth.

Their results are shown in the table. Age 0 days = day of birth.

Age / days	Percentage of heart cells undergoing mitosis	Percentage of heart cells undergoing DNA replication
−6	13.9	8.5
4	8.5	2.6
14	1.6	0.2
21	0.6	0.0

(a) Describe and explain the data in the table above.

(2)

Q7.

(a) A student prepared a stained squash of cells from the tip of an onion root and observed it using an optical microscope.

During the preparation of the slide, he:

- cut the first 5 mm from the tip of an onion root and placed it on a glass slide
- covered this tip with a drop of stain solution and a cover slip
- warmed the glass slide
- pressed down firmly on the cover slip.

He identified and counted nuclei in different stages of the cell cycle.

Explain why the student:

1. used only the first 5 mm from the tip of an onion root.

_____

_____

_____

_____

_____

2. pressed down firmly on the cover slip.

_____

_____

_____

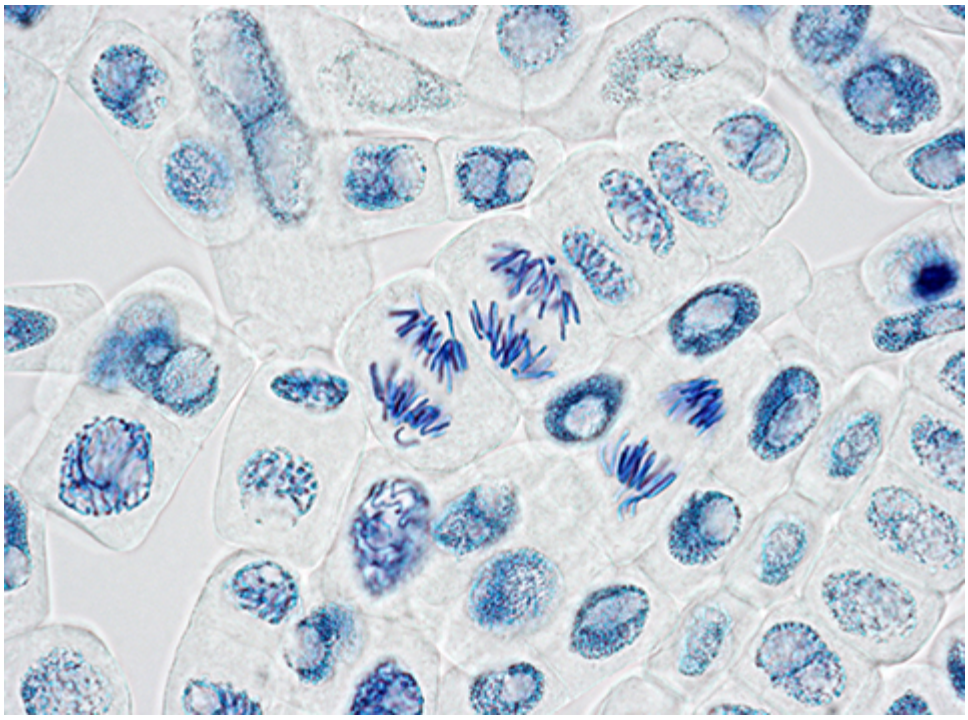
_____

_____

(2)

Figure 1 shows the cells the student saw in one field of view. He used this field of view to calculate the length of time these onion cells spent in anaphase of mitosis.

Figure 1



(b) Scientists have found the mean length of time spent by onion cells in anaphase of mitosis is 105 minutes. They also found the cell cycle of cells in the onion root shown in **Figure 1** takes 1080 minutes.

32 whole cells are shown in **Figure 1**.

Use this information and **Figure 1** to calculate the length of time the cells of this onion root are in anaphase **and** then calculate the percentage difference between your answer and the mean length of time found by the **scientists**.

Show your working.

Answer = _____ %

(2)

(c) Tick (✓) the name given to the division of cytoplasm during the cell cycle.

A Binary fission ☐

B Cytokinesis ☐

C Phagocytosis ☐

D Segregation ☐

(1)

(d) Describe and explain what the student should have done when counting cells to make sure that the mitotic index he obtained for this root tip was accurate.

_____

_____

_____

_____

_____

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_____

_____

_____

_____

(2)

(e) A scientist treated growing tips of onion roots with a chemical that stops roots growing. After 24 hours, he prepared a stained squash of these root tips.

Figure 2 is a drawing showing the chromosomes in a single cell observed in the squash of one of these root tips in anaphase. This cell was typical of other cells in anaphase in these root tips.

Figure 2

Use all of this information to suggest how the chemical stops the growth of roots.

(3)

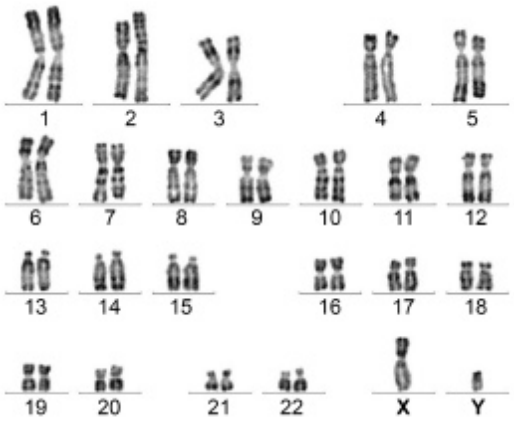
(Total 10 marks)

Q8.

Figure 1 shows all the chromosomes present in one human cell during mitosis. A scientist stained and photographed the chromosomes. In **Figure 2**, the scientist has arranged the images of these chromosomes in homologous pairs.

Figure 1

Figure 2



(a) Give **two** pieces of evidence from **Figure 1** that this cell was undergoing mitosis. Explain your answers.

1. _____

_____

_____

_____

_____

_____

2. _____

_____

_____

_____

_____

_____

(2)

(b) Tick (✓) **one** box that gives the name of the stage of mitosis shown in **Figure 1**.

A Anaphase ☐

B Interphase ☐

C Prophase ☐

D Telophase ☐

(1)

(c) When preparing the cells for observation the scientist placed them in a solution that had a slightly higher (less negative) water potential than the cytoplasm. This did not cause the cells to burst but moved the chromosomes further apart in order to reduce the overlapping of the chromosomes when observed with an optical microscope.

Suggest how this procedure moved the chromosomes apart.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(2)

(d) The dark stain used on the chromosomes binds more to some areas of the chromosomes than others, giving the chromosomes a striped appearance.

Suggest **one** way the structure of the chromosome could differ along its length to result in the stain binding more in some areas.

_____

_____

_____

_____

_____

(1)

(e) In **Figure 2** the chromosomes are arranged in homologous pairs.
What is a homologous pair of chromosomes?

_____

_____

_____

_____

_____

(1)

Q9.

(a) Name the process by which bacterial cells divide.

_____

(1)

A microbiologist investigated the ability of different plant oils to kill the bacterium *Listeria monocytogenes*. She cultured the bacteria on agar plates. She obtained the bacteria from a broth culture.

(b) Describe **two** aseptic techniques she would have used when transferring a sample of broth culture on to an agar plate.
Explain why each was important.

_____

_____

_____

_____

_____

(4)

Q10.

(a) Describe the appearance and behaviour of chromosomes during mitosis.

(5)

Q11.

A student investigated mitosis in the tissue from an onion root tip.

(a) The student prepared a temporary mount of the onion tissue on a glass slide. She covered the tissue with a cover slip. She was then given the following instruction.

"Push down hard on the cover slip, but do not push the cover slip sideways."

Explain why she was given this instruction.

_____

_____

_____

_____

(2)

The image below shows one cell the student saw in the onion tissue.

© Ed Reschke/
Oxford Scientific/Getty Images

(b) The student concluded that the cell in the image above was in the anaphase stage of mitosis.
Was she correct? Give **two** reasons for your answer.

1. _____

_____

2. _____

_____

(2)

(c) The student counted the number of cells she observed in each stage of mitosis.
Of the 200 cells she counted, only six were in anaphase.

One cell cycle of onion root tissue takes 16 hours. Calculate how many minutes these cells spend in anaphase.

Show your working.

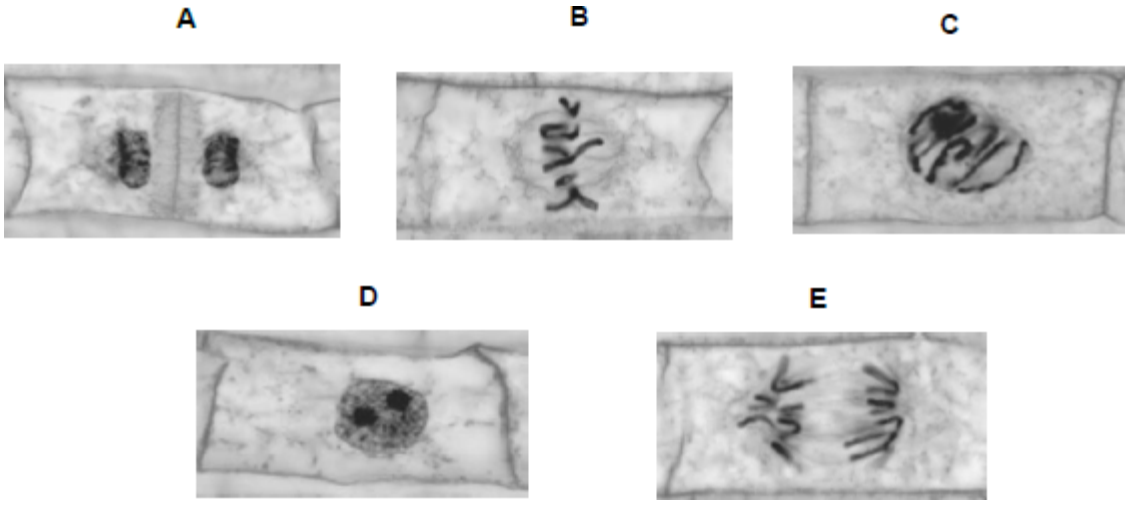
Answer = _____ minutes

(2)

(Total 6 marks)

Q12.

The figure below shows some cells from an onion root tip at different stages of the cell cycle.



© Ed Reschke/Oxford Scientific/Getty Images

(a) Place stages **A** to **E** in the correct order. Start with stage **D**.

D_____

(1)

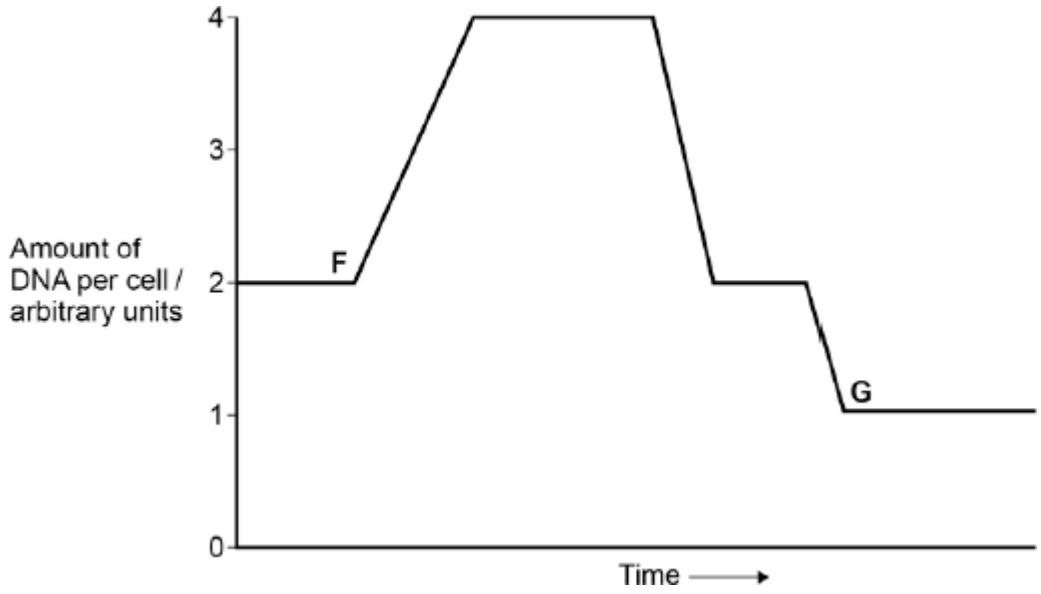
To obtain these images, the onion root tip was cut off, stained and put on a microscope slide. A cover slip was placed on top. The root tip was then firmly squashed and viewed under an optical microscope.

(b) Complete the table below to give **one** reason why each of these steps was necessary.

Step	Reason
Taking cells from the root tip	
Firmly squashing the root tip	

(2)

The figure below shows how the amount of DNA per cell changed during interphase and meiosis in an animal.



(c) Explain how the behaviour of chromosomes causes these changes in the amount of DNA per cell between **F** and **G**.

(3)

(d) What would happen to the amount of DNA per cell at fertilisation of cell **G?**

(1)

(Total 7 marks)