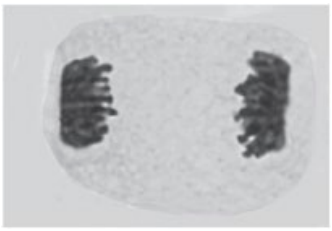
1(a). The cell cycle describes a series of events that occur during the life of a cell.

Complete the sentences by choosing the most appropriate terms.

During mitosis the ..... divides. This is followed immediately by ..... .
Interphase contains three phases. Replication of DNA takes place during the ..... phase.
Checkpoints occur during the cell cycle. The G1 and G2 checkpoints check for cell size and ..... . The second checkpoint occurs at the end of the ..... phase. If a cell does not satisfy the requirements of a checkpoint, it enters the ..... .

[6]

(b). The image shows an onion cell undergoing mitosis.



i. Name the stage of mitosis shown in the image.

[1]

ii. Describe how the image would look different if the cell was in interphase.

[2]

iii. The cell in the image is from the root of an onion.

State why root tissue is frequently chosen to study mitosis.

[1]

(c). The stages of mitosis and meiosis are similar but not identical.

Prophase occurs in both mitosis and meiosis.

i. At the beginning of mitosis and meiosis, the nuclear envelope disintegrates.

Identify **two** other similarities between prophase in mitosis and **prophase** 1 of meiosis.

1 _____

_____

2 _____

_____ **[2]**

ii. Identify **one** difference between prophase in mitosis and **prophase 2** of meiosis.

_____

_____

_____ **[1]**

(d). The cell cycle of an onion cell is estimated to be 15 h.

A root-tip squash from an onion contained 124 cells.

16 of the cells were undergoing mitosis.

Calculate the mean length of time each cell spent undergoing mitosis.

Give your answer in minutes to **3** significant figures.

Time spent undergoing mitosis = ... min **[2]**

2. In the future, type 1 diabetes could be treated by giving patients new pancreatic β-cells that have been produced in a laboratory from stem cells.

i. State a feature of stem cells that allows them to be used to produce pancreatic β-cells.

_____

_____ **[1]**

ii. Future treatments for type 1 diabetes may be able to use stem cells from a patient's body to produce new β-cells.

Explain why patients receiving these new β-cells would still need to be given immunosuppressant drugs.

---**[1]**

3. Xylem vessels maintain the transpiration stream by transporting water up plant stems.

The sentences describe the role of meristems in producing xylem vessels.

Complete the sentences using the most appropriate words or phrases.

Meristem cells are located between xylem and ..... tissues in plants. Cells of either of these vascular tissues can be produced when meristem cells divide and ..... .

[2]

4. State the difference between a tissue and an organ.

---**[1]**

5(a). DNA has a double helix structure made from polynucleotides.

DNA is replicated during interphase of the eukaryotic cell cycle.

i. The enzyme helicase is active during DNA replication.

Describe the action of helicase.

---**[2]**

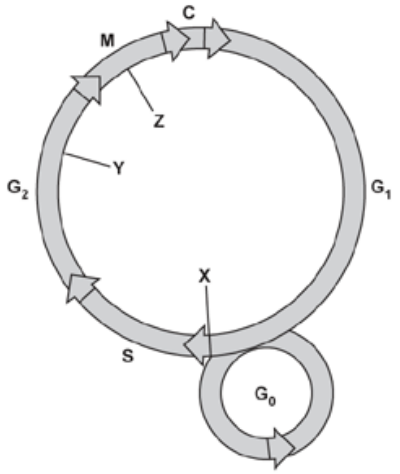
ii. DNA replication conserves genetic information with accuracy.

Explain how errors may occur during DNA replication.

---**[2]**

(b). An outline of the eukaryotic cell cycle is shown.

X, **Y** and **Z** represent checkpoints in the regulation of the cell cycle.

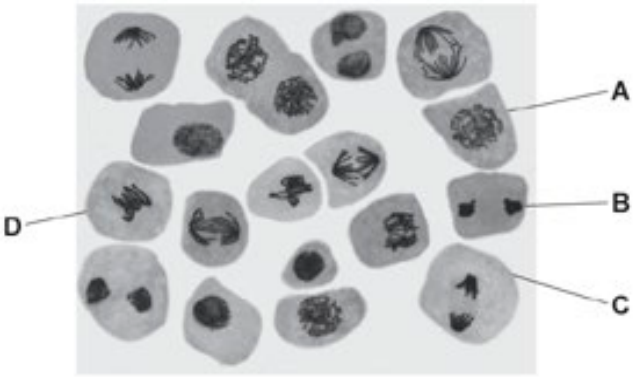


A cell that had completed the cell cycle had more chromosomes than its normal diploid number.

Identify which cell cycle checkpoint, **X**, **Y** or **Z**, had failed to work in this cell. Give a reason for your choice.

[2]

6. The photomicrograph shows a group of cells prepared from an onion root tip squash.



Which of the label lines shows a cell that is in metaphase?

Your answer ☐ **[1]**

7(a). Many organisms undergo asexual reproduction by mitosis.

State **two** other roles of mitosis in organisms.

1 _____

2 _____ **[1]**

(b). Plants reproduce asexually by mitosis.

i. Explain why mitosis, and not meiosis, is used for asexual reproduction in plants.

_____

_____

_____

_____

[2]

ii. Bacteria reproduce asexually by a process called binary fission.

Suggest why bacteria are unable to reproduce asexually by mitosis.

_____

_____

_____

_____

[2]

8. Which statement is true of stem cells?

A All stem cells can naturally divide to produce a new organism.
B Stem cells are differentiated and specialised cells.
C Stem cells are found only in early embryos.
D Stem cells in adult humans can divide into a limited range of cell types.

Your answer ☐ **[1]**

9. Which option correctly describes a tissue?

A A group of cells performing similar functions
B A group of organs performing a specific function
C A group of similar cells performing a specific function
D A group of similar cells performing a variety of functions

Your answer ☐ **[1]**

10. Bone marrow stem cells are a source of erythrocytes.

Which statement about bone marrow stem cells and their role in the production of erythrocytes is correct?

A Bone marrow stem cells are totipotent and can therefore differentiate into any type of cell.
B Erythrocytes are the only blood cell produced from bone marrow stem cells.
C Erythrocytes need to be replaced from bone marrow stem cells because erythrocytes are unable to undergo mitosis.
D In humans, differentiation of bone marrow stem cells into erythrocytes involves the synthesis of a haploid nucleus.

Your answer ☐ **[1]**

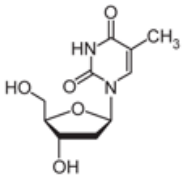
11. Which option correctly describes the sequence of events during the cell cycle?

A Cytokinesis → interphase → G_1 → G_2 → S → mitosis
B Cytokinesis → mitosis → interphase
C G_2 → mitosis → cytokinesis → G_1 → S
D Mitosis → interphase → cytokinesis

Your answer ☐ **[1]**

12. Vitamins are molecules that are consumed in the diet of animals and have essential roles in the body.

Vitamin B_9 is needed for the synthesis of molecule **D**, shown in the figure below.



Molecule **D**

Molecule **D** is a component in the structure of DNA.

A deficiency of vitamin B_9 in the diet can cause interphase to stop in some cells.

Use this figure to explain why a deficiency of vitamin B_9 can cause interphase to stop.

_____

_____

_____

_____

_____ **[2]**

13. Parkinson's disease is a neurological condition which results in problems with co-ordination of body movements.

- It can be caused by the death of dopamine producing nerve cells in a part of the midbrain called the substantia nigra.
- Body movements become slow and abnormal due to reduction in dopamine.
- Drugs are available but they only slow down the progress of Parkinson's disease.

Suggest and explain how stem cells might be used to help treat Parkinson's disease.

[2]

14(a). Here is some information about reproduction in two members of the animal kingdom.

- Komodo dragons are large lizards that usually reproduce sexually, but very rarely females can reproduce asexually.
- Starfish can reproduce asexually by a process known as fragmentation. This is when a small piece of the adult starfish breaks off and starts to grow on its own to form a clone of its parent.

i. Describe the role of mitosis in fragmentation.

[2]

ii. State **one** other function of mitosis in starfish.

[1]

iii. When Komodo dragons reproduce sexually the gametes are produced by meiosis.

Explain how meiosis produces genetic variation in the offspring.

[3]

(b). HeLa cells and RPE1 cells are cell lines that are commonly used in research. Scientists can use these cell lines to observe mitosis in human tissues outside the human body.

Scientists use the term mitotic index to describe the proportion of cells in a sample that are undergoing mitosis.

A study was carried out using a chemical CDK1. This chemical increased the mitotic index of HeLa and RPE1 cells so that mitosis could be better observed.

Here are the results from the study:

- 31 HeLa cells were found to be undergoing mitosis in the field of view through a microscope.
- The mitotic index for HeLa cells was found to be 0.36.
- The mitotic index for RPE1 cells was found to be 0.16.
- Total number of RPE1 cells in the field of view were 75.

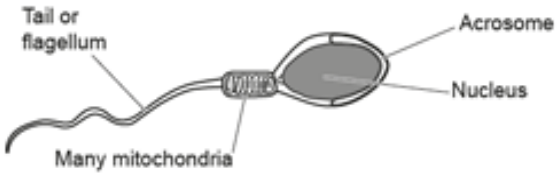
Calculate the total number of HeLa cells that were in the field of view.

$$\text{Use the formula: Mitotic index} = \frac{\text{Number of cells in the field of view undergoing mitosis}}{\text{Total number of cells in the field of view}}$$

Give your answer to **2** significant figures.

Total number of HeLa cells = ... **[2]**

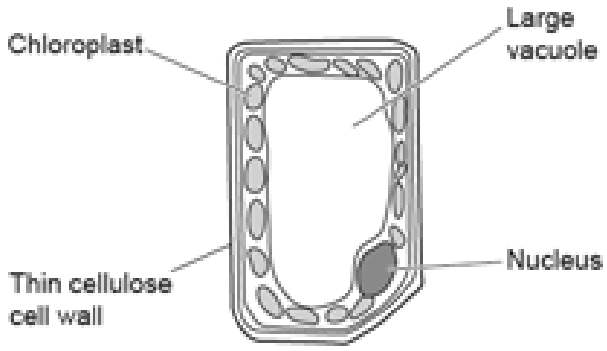
15(a). The figure shows a sperm cell from a mammal.



With reference to the features shown in the figure of a sperm cell above, explain how the sperm cell is adapted to its function.

[2]

(b).



With reference to the features shown in the figure of a palisade cell above, explain how the palisade cell is adapted to its function.

[2]

16. The sea sponge, *Aplysina aerophoba*, and the zebra shark, *Stegostoma fasciatum*, are both animals.

Both *A. aerophoba* and *S. fasciatum* reproduce sexually, but under particular conditions they

are both able to reproduce asexually.

In asexual reproduction in *A. aerophoba*:

- clumps of diploid cells detach from the body of the sponge
- the cells reattach to a surface and grow into new, adult sponges.

In asexual reproduction in *S. fasciatum*:

- meiosis occurs in a female
- two of the haploid cells produced by meiosis fuse to form a diploid cell
- the diploid cell develops into a new shark.

A student stated, 'When they reproduce asexually, both animals produce clones of themselves.'

Evaluate the student's statement.

[3]

17. Fig. 2.1 shows a light micrograph of a blood smear.

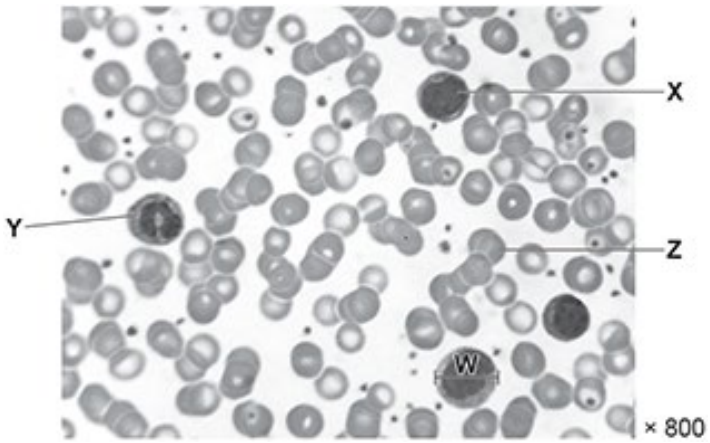


Fig. 2.1

i. The cells labelled **X** and **Y** in **Fig. 2.1** are two different types of white blood cell.

Identify the types of white blood cell labelled **X** and **Y**.

X _____

Y _____

[2]

ii. The blood cell labelled **Z** in **Fig. 2.1** contains a high concentration of haemoglobin.

Outline **two** other ways in which the blood cell labelled **Z** is adapted for its function.

_____

_____

_____

_____

[2]

iii. The diameter of another blood cell is represented by the line **W** in **Fig. 2.1**.

The magnification used to produce **Fig. 2.1** was × 800.

Calculate the actual diameter, **W**, of the blood cell.

Give your answer in μm.

Diameter = ... μm [2]

18(a). Fig. 2.1 shows the larva of a European stag beetle, *Lucanus cervus*.

Fig. 2.1

These larvae can live for up to six years, feeding and growing in decaying wood. During this time,the cells in the larvae undergo mitosis to produce genetically identical cells.

Mitosis is part of the cell cycle. The cell cycle is shown in **Fig. 2.2**.

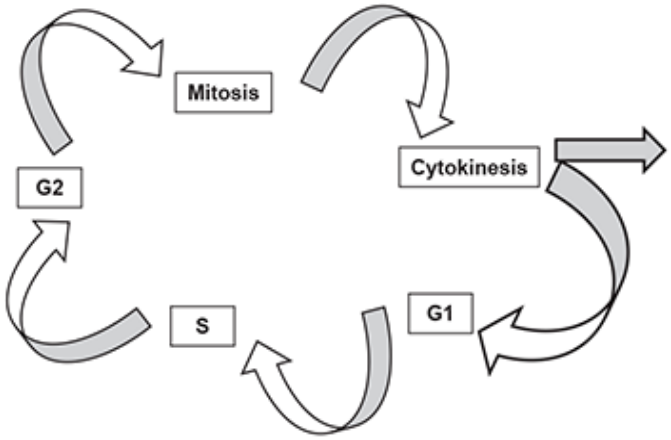


Fig. 2.2

i. The size of the cell increases during stage **G2** in the cell cycle.

State **one** other process that takes place during stage **G2**.

_____ **[1]**

The length of a stag beetle larva was measured at yearly intervals and some of the data plotted onto the graph shown in **Fig. 2.3**.

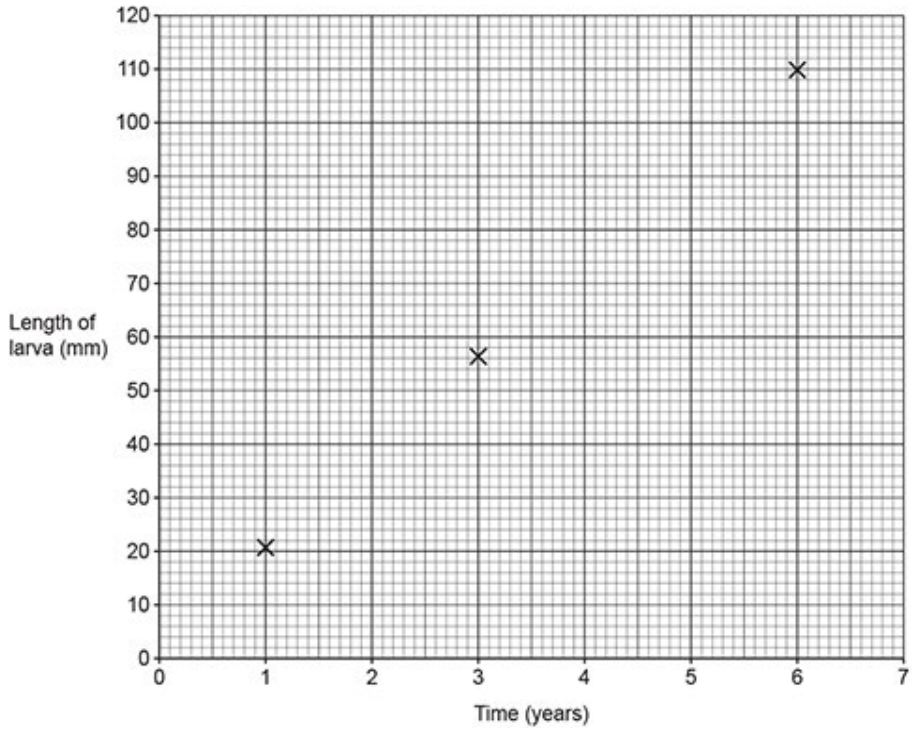


Fig. 2.3

ii. Assuming that the growth of the larva follows a relationship of y = mx + c, use **Fig. 2.3** to determine the length of the larva at 0 years, when it emerges from the egg.

Length of larva = ... mm **[1]**

iii. Calculate the growth rate of the larva.

Growth rate = ... mm $year^{-1}$ **[2]**

(b). A group of students were investigating mitosis. They examined cells from onion root tip squashes that had been prepared using acetic orcein stain. Chromosomes appear a purple red colour when this stain is used.

Fig. 2.4 shows a light micrograph of one of these cells. A student stated that this cell was at metaphase.

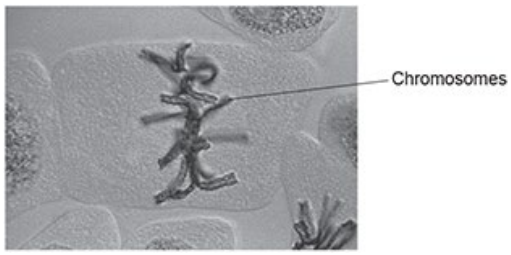


Fig. 2.4

i. Describe how **Fig. 2.4** shows the importance of differential staining for observing cells undergoing mitosis.

[1]

ii. Identify one piece of evidence that would have led the students to conclude that the cell in **Fig. 2.4** is at metaphase.

[1]

iii. Three students were studying onion root tip squashes under the microscope. They recorded the number of cells at each stage of mitosis. A record of their observations is shown below.

Student 1:	Metaphase 1 cell
	Anaphase 3 cells
	Prophase 3 cells
Student 2:	Anaphase 4 cells
	Prophase 5 cells
	Telophase 1 cell
Student 3:	Telophase 3 cells
	Metaphase 5 cells
	Prophase 2 cells

In the space below draw an appropriate table to present the students' observations.

Include the headings for the columns. You are **not** required to enter any of the results into your table.

[2]

(c). Compare prophase in mitosis with prophase in meiosis.

[4]

19. Fig. 4.1 shows a light micrograph of cells in the blood.

Cell **X** plays a role in the immune response.

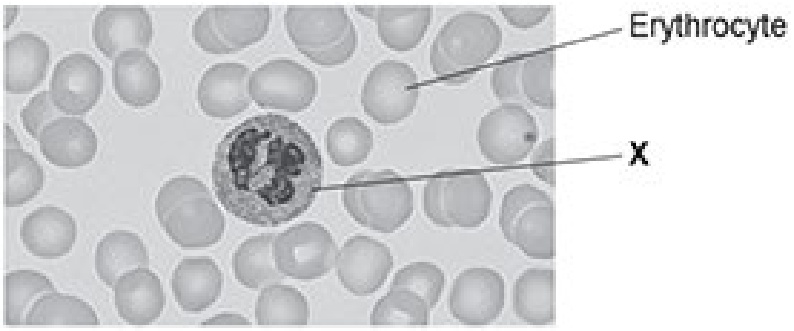


Fig. 4.1

i. Name cell **X**.

[1]

ii. The magnification of the microscope used to observe the cells in **Fig. 4.1** was ×950.

Calculate the diameter of cell **X** in **Fig. 4.1**.

Give your answer in micrometres.

Diameter = ... μm **[2]**

iii. Using **Fig. 4.1**, explain why blood is described as a tissue and not an organ.

[1]

20. Hypothyroidism (underactive thyroid gland) is treated by taking thyroxine tablets.

Scientists are investigating the use of stem cell transplants to treat hypothyroidism in which the thyroid glands of mice are destroyed using radioactive iodine.

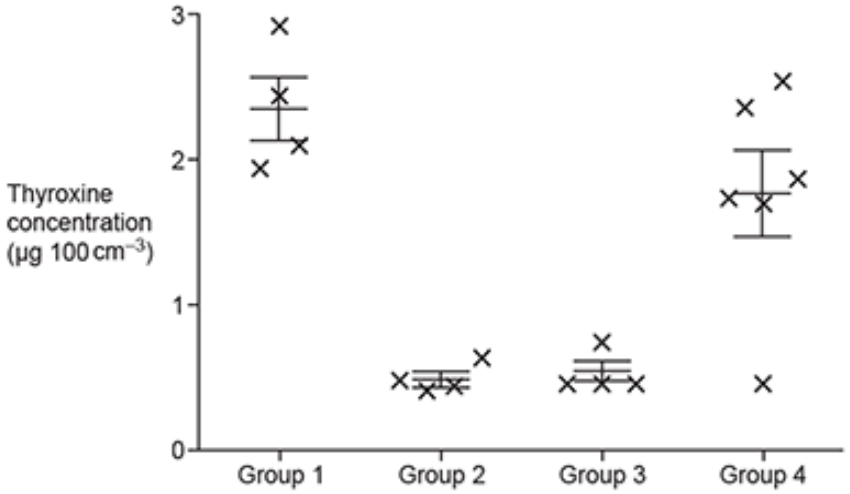
The scientists obtained mouse embryonic stem cells (ESCs) and incubated them in culture with or without a mixture of growth factors for 30 days before transplanting them into the mice.

They divided the mice into four groups as shown in the table.

Group	Thyroid gland destroyed	ESCs transplanted into mice
1	No	No
2	Yes	No
3	Yes	Yes, incubated in culture without growth factors
4	Yes	Yes, incubated in culture with growth factors

After eight weeks they measured the thyroxine concentration in the four groups of mice.

Their results are shown in the graph. Each cross represents a single mouse and the mean ± 2 standard deviations is shown for each group.



i. The ESCs are described as pluripotent.

Explain what is meant by pluripotent.

[2]

ii. The scientists concluded that growing the ESCs with growth factors caused them to differentiate into functional thyroid tissue.

Evaluate this conclusion.

[3]

iii. The scientists then repeated their experiments with adult stem cells taken from the skin of patients with hypothyroidism. These cells were artificially transformed into pluripotent stem cells (iPSCs).

The scientists concluded that use of human iPSCs would be **safer** than using human ESCs to treat hypothyroidism.

Use your knowledge of stem cells to suggest one reason that supports and one reason that does not support the scientists' conclusion.

Supports _____

_____

_____

Does not support _____

_____

_____

[2]

21(a). Explain the role of meristem tissue in a stem.

_____

_____

_____

_____

[2]

(b). Name **one** potential use of stem cells in medicine.

_____

[1]

END OF QUESTION PAPER