A-Level Biology

Meiosis

Question Paper

Time available: 65 minutes
Marks available: 49 marks

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1. (a) In taxonomy, an organism is identified by referring to the species name and the genus name.

What term is used to describe this method of naming organisms?

_____

(1)

(b) Define the term mutagenic agent.

_____

_____

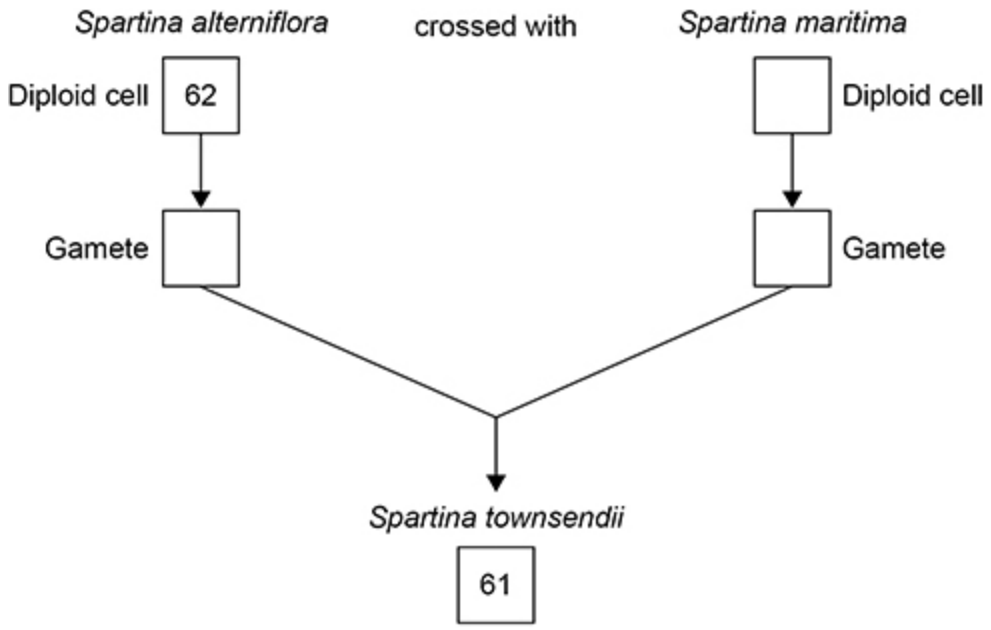
_____

(1)

(c) **Figure 1** shows how the species *Spartina townsendii* is produced.

The number of chromosomes in cells is shown in some of the boxes.

Figure 1



Complete **Figure 1** by giving the correct number of chromosomes in each of the boxes.

(1)

A mutation in the number of chromosomes in a *S. townsendii* cell produced a new species, *Spartina anglica*.

Figure 2 shows the number of chromosomes in leaf cells of these species.

Figure 2

(d) Name the type of mutation that changed the number of chromosomes in *S. townsendii* to produce *S. anglica*. Explain your answer.

Name of mutation _____

Explanation _____

_____

_____

_____

_____

_____

_____

_____

(3)

(e) Genetic variation within a species is increased during meiosis by crossing over and the independent segregation of homologous chromosomes.

Apart from mutation, explain **one** other way genetic variation within a species is increased.

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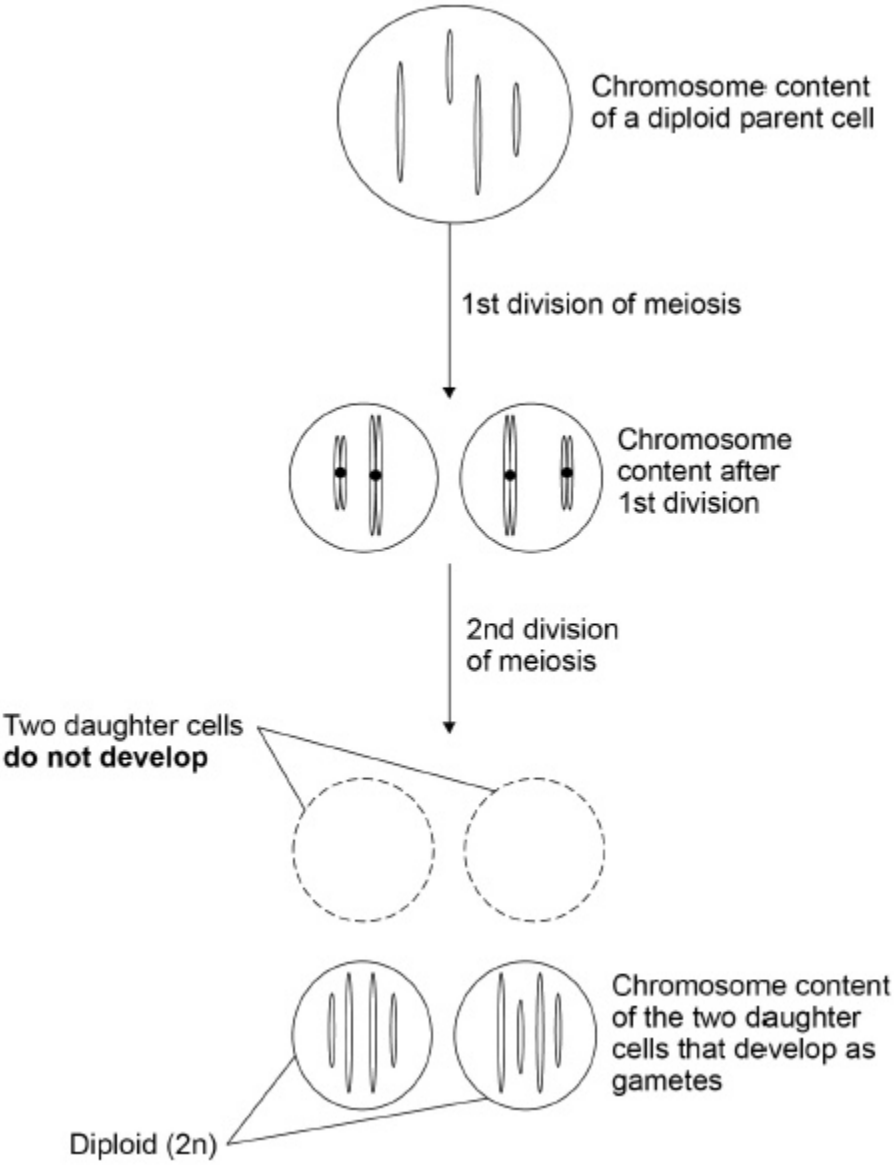
(2)

(Total 8 marks)

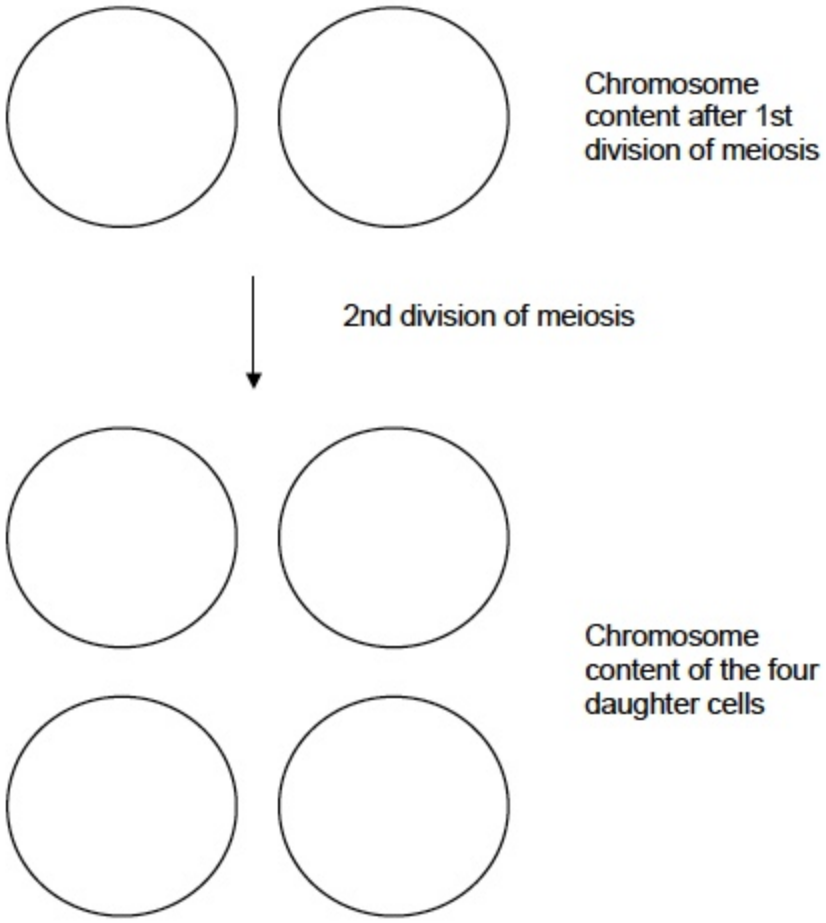
2. **Figure 1** shows a faulty form of meiosis that can occur in some plants.

Figure 1



(a) Complete **Figure 2** to show the chromosome content of the cells that would result from a normal meiotic division of the diploid parent cell shown in **Figure 1**.

Figure 2



(2)

(b) If two diploid (2n) gametes fuse at fertilisation, it can result in the growth of a tetraploid plant which has 4 copies of each chromosome.

Red clover is a plant grown to produce cattle feed. Tetraploid red clover plants produce a higher yield than diploid red clover plants.

Whether a red clover plant produces 2n gametes is genetically controlled.

Scientists investigated the possibility of breeding red clover plants that only produced 2n gametes.

- In breeding cycle 0, they grew red clover plants and identified plants that produced 2n gametes.
- In breeding cycle 1, they used the plants producing 2n gametes to produce offspring.
- In breeding cycles 2 and 3, they identified plants producing 2n gametes and used these to produce offspring.

Their results are shown in the table.

	Observed		Expected	
Breeding cycle	Number of plants that **did not** produce 2n gametes	Number of plants that **did** produce 2n gametes	Number of plants that **did not** produce 2n gametes	Number of plants that **did** produce 2n gametes
0	50	4	50	4
1	14	42		
2	2	44		
3	0	56		

The scientists used the following null hypothesis.

'The proportion of plants that produce 2n gametes will not change from one breeding cycle to the next.'

Complete the table to show the **expected number** of plants that **did not** produce 2n gametes and the expected number of plants that **did** produce 2n gametes after 1 cycle. Give each answer to the nearest whole number.

(2)

(c) The scientists tested their null hypothesis using the chi-squared statistical test.
After 1 cycle their calculated chi-squared value was 350
The critical value at P=0.05 is 3.841

What does this result suggest about the difference between the observed and expected results and what can the scientists therefore conclude?

_____

_____

_____

_____

_____

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_____

(2)

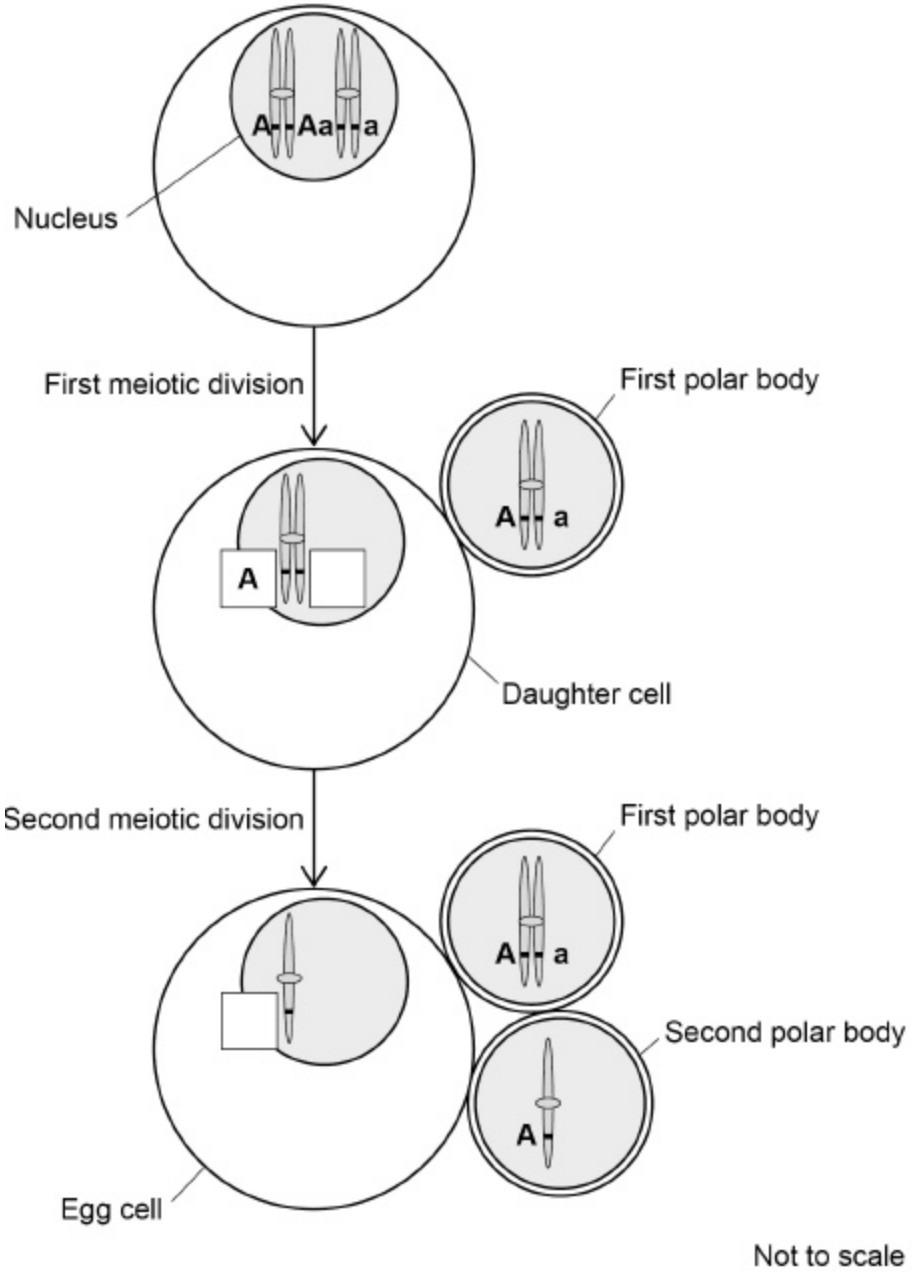
(d) Use your knowledge of directional selection to explain the results shown in the table.

(3)

(Total 9 marks)

3. In women, the first division of meiosis produces one daughter cell that has almost all of the cytoplasm. The other daughter cell consists of a nucleus surrounded by a very small amount of cytoplasm and a cell-surface membrane. This very small daughter cell is called a polar body. Polar bodies do not usually divide. The same process occurs in the second division of meiosis, resulting in one egg cell and two polar bodies.

The diagram shows the formation of an egg cell and two polar bodies during meiosis. It also shows what happens to one pair of homologous chromosomes. This pair carries two alleles of gene A.



(a) Complete the diagram by putting **A** or **a** in the boxes. One box has been completed for you with **A**.

(1)

(b) Put a tick (✓) in the box next to the name of the process that produced the combination of alleles on the chromosome in the first polar body in the diagram.

Anaphase ☐

Crossing over ☐

Independent assortment ☐

Semi-conservative replication ☐

(1)

(c) A scientist measured the diameter of a polar body and the diameter of the nucleus inside it. The diameter of the polar body was 10.4 μm and the diameter of the nucleus was 7.0 μm. The density of mitochondria in the cytoplasm of the polar body (outside of the nucleus) was 0.08 mitochondria per μm^3.

Calculate the number of mitochondria in the polar body. You should assume polar bodies and nuclei are spherical.

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

Show your working.

Number of mitochondria =_____

(2)

(d) Mitochondrial diseases are caused by faulty mitochondria. All of a person's mitochondria are inherited from their mother via the egg cell. An egg cell contains approximately 3×10^5 mitochondria.

One proposed treatment to prevent passing on faulty mitochondria involves

- removing the nucleus from an egg cell donated by a woman with healthy mitochondria
- replacing this nucleus with the contents of the polar body from a woman whose egg cells are affected by mitochondrial disease.

Suggest how this treatment prevents inheritance of mitochondrial diseases.

_____

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(2)

(e) If most of the mitochondria in a cell are faulty, this prevents many important enzyme-catalysed reactions taking place or slows them down.

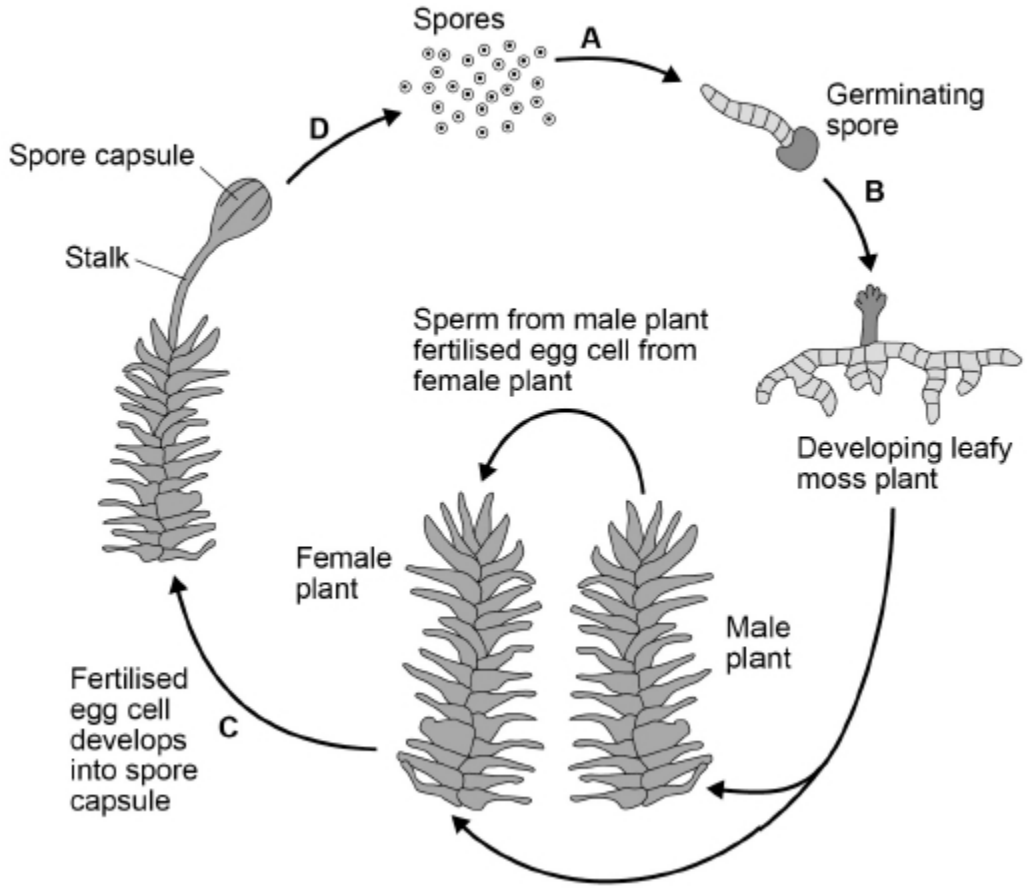
Suggest and explain **one** reason why.

(2)

(Total 8 marks)

4. **Figure 1** shows the life cycle of a moss plant. In this life cycle, **only** the stalk and spore capsule are **diploid**. All the cells in all the other stages of the life cycle of the moss are **haploid**.

Figure 1



(a) Which letter, **A**, **B**, **C** or **D**, in **Figure 1**, shows where meiosis occurs in the life cycle of the moss? Write the appropriate letter in the box provided.

(1)

(b) Explain how the chromosome number is halved during meiosis.

(2)

(c) **Figure 2** shows a cell from the moss plant.

The cell is in the **second** meiotic division.

Figure 2

What is the haploid number of chromosomes for this species of moss?

(1)

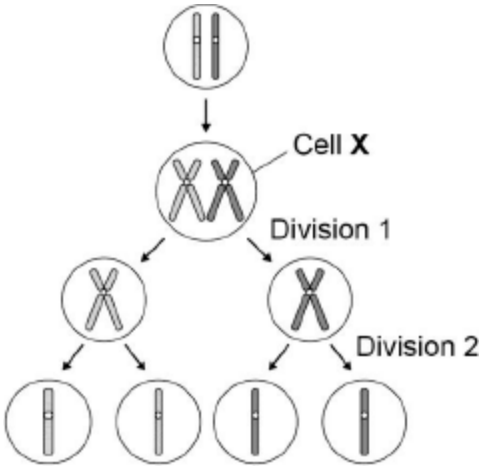
(d) Crossing over greatly increases genetic diversity in this species of moss.

Describe the process of crossing over and explain how it increases genetic diversity.

(4)

(Total 8 marks)

5. The figure below summarises the process of meiosis. The circles represent cells and the structures within each cell represent chromosomes.



(a) Describe and explain the appearance of **one** of the chromosomes in cell **X**.

(3)

(b) Describe what has happened during division 1 in the figure above.

_____

_____

_____

_____

_____

_____

(2)

(c) Identify **one** event that occurred during division 2 but **not** during division 1.

_____

(1)

(d) Name **two** ways in which meiosis produces genetic variation.

1. _____

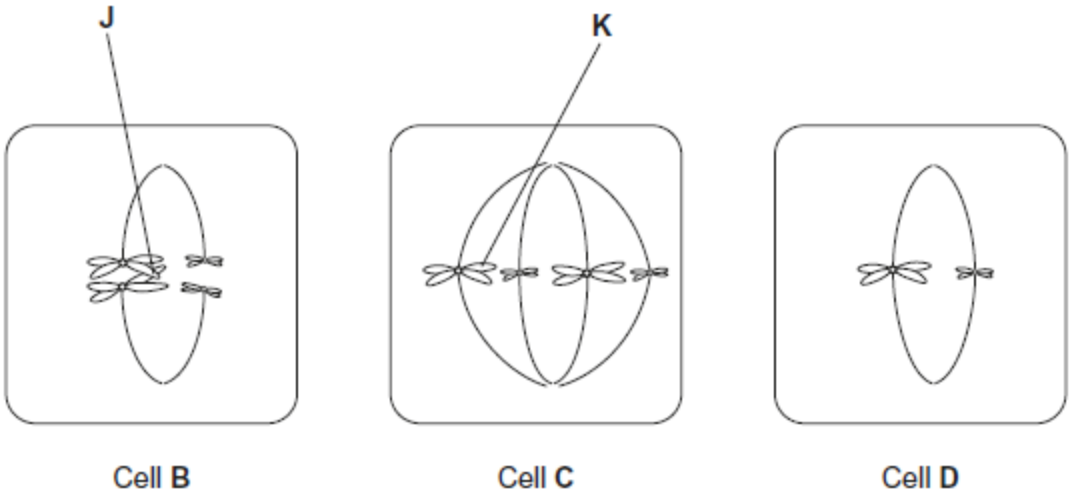
2. _____

(2)

(Total 8 marks)

6. **Figure 1** shows three cells, **B**, **C** and **D**, from tissues in the same organism. Each cell is in a stage of either mitosis or meiosis.

Figure 1



(a) Complete the table with a tick if the cell shows the feature.

	Cell B	**Cell C**	**Cell D**
homologous chromosomes are present			
a stage of mitosis			

(2)

(b) Describe and explain the appearance of chromosome **K** in cell **C**.

(2)

(c) Explain what is happening at point **J** in cell **B**.

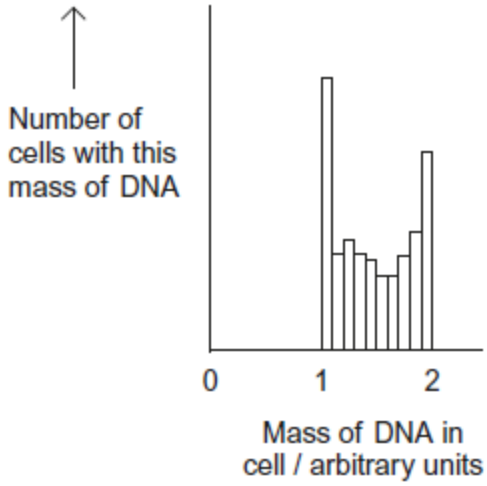
(2)

(d) Use information from all three cells in **Figure 1** to explain how the number of chromosomes in cell **D** was produced.

(1)

(e) **Figure 2** shows the mass of DNA present in cells of a population of healthy cells where mitosis is occurring.

Figure 2



Explain why some cells contain a mass of DNA between 1 and 2 arbitrary units.

_____

_____

_____

(1)

(Total 8 marks)