

2025 JC2 PRELIMINARY EXAMINATIONS

CANDIDATE
NAME

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CLASS

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INDEX
NUMBER

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BIOLOGY

9744/02

Paper 2 Structured Questions

22 August 2025
Friday

Candidates answer on the Question Paper.
No Additional Materials are required.

2 Hours

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graph.
Do not use paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

The use of an approved scientific calculator is expected,
where appropriate.
You may lose marks if you do not show your working or if you
do not use appropriate units.

The number of marks is given in brackets [] at the end of each
question or part question.

For Examiner's Use	
1	/ 9
2	/ 9
3	/ 11
4	/ 10
5	/ 10
6	/ 9
7	/ 10
8	/ 10
9	/ 10
10	/ 7
11	/ 5
Total	/100

Answer **all** the questions.

- 1 Stem cells are found throughout the human body. Lgr5⁺ stem cells are found in the lining of the small intestine.

Fig. 1.1 shows stages in the development of one of the daughter cells produced by the mitotic division of an Lgr5⁺ stem cell.

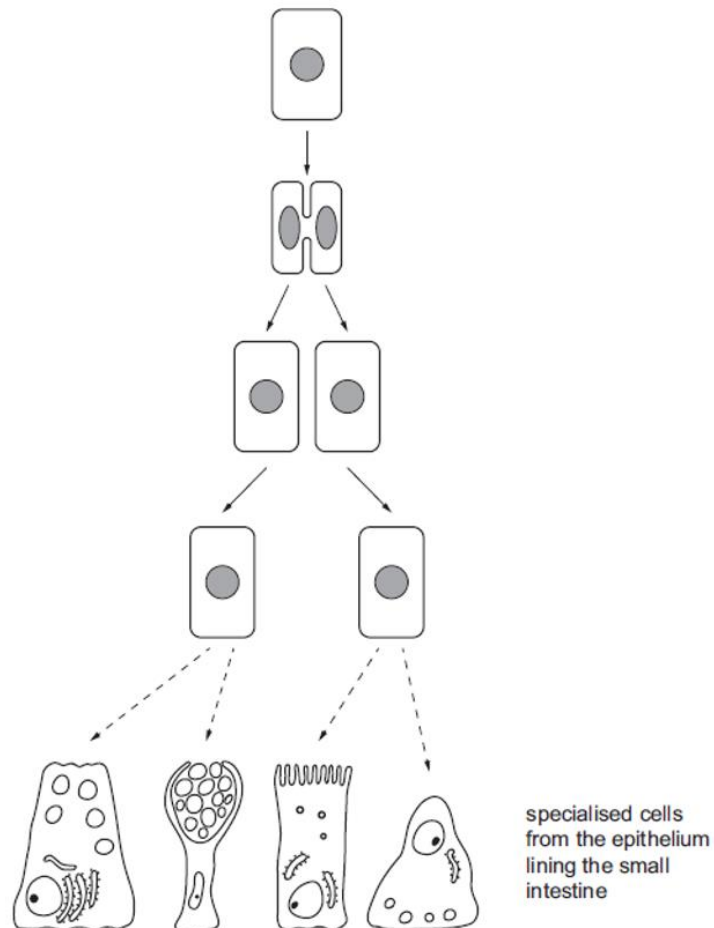


Fig. 1.1

- (a) Explain why Lgr5⁺ stem cells are required in the lining of the small intestine.

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- (b) Fig. 1.2 shows a goblet cell, one of the specialised cells that develops from Lgr5⁺ stem cells in the small intestine.

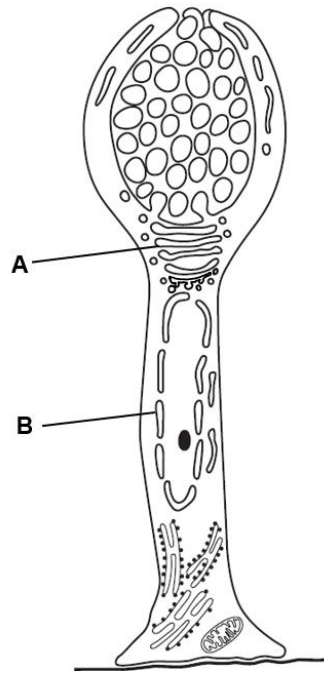


Fig. 1.2

Identify the structures labelled **A** and **B**, as shown in Fig. 1.2.

For each structure, state its function **and one** identifying feature that can be seen in Fig. 1.2.

structure **A**

function

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identifying feature

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structure **B**

function

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identifying feature

.....[6]

[Total: 9]

- 2 Neutrase® is an enzyme that is used to hydrolyse proteins in solution. When the enzyme is mixed with a 2% protein solution, the reaction mixture changes from white to colourless.

A student carried out an experiment to find the effect of copper sulfate and potassium sulfate on the activity of Neutrase®.

The student made four reaction mixtures in test-tubes **A** to **D**. Test-tubes **A** to **C** contained equal volumes of protein solution and 0.1cm^3 of solutions of copper sulfate or potassium sulfate. Test-tube **D** contained the same volume of protein solution and 0.1cm^3 of water.

0.5cm^3 of a 1% Neutrase® solution was added to test-tube **A** and immediately placed into a colorimeter. The colorimeter was used to measure the intensity of light that is absorbed by the solution (absorbance) over 100 seconds. The procedure was repeated with the other reaction mixtures, **B**, **C** and **D**.

The results are shown in Fig. 2.1.

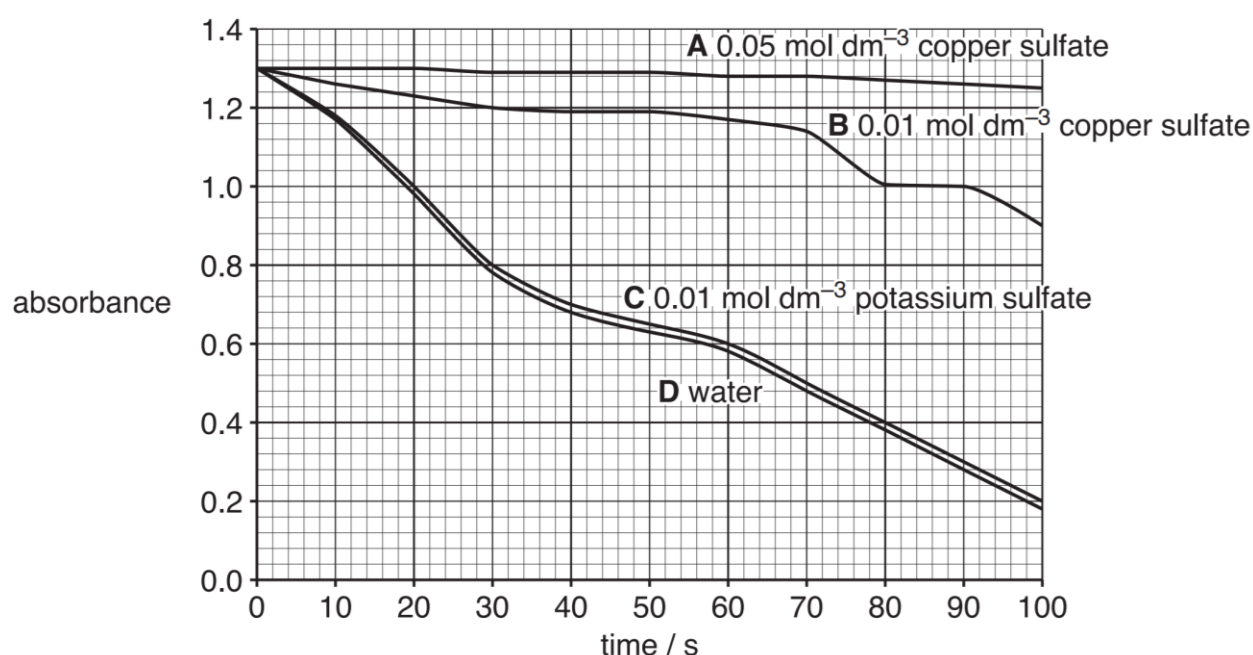


Fig. 2.1

- (a) Suggest **and** explain why measuring the absorbance of the reaction mixture over 100 s is a suitable method for determining the activity of Neutrase®.

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(b) With reference to Fig. 2.1,

- (i)** describe the effects of copper sulfate solution and potassium sulfate solution on the activity of Neutrase®.

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- (ii)** suggest explanations for the effects described in **(b)(i)**.

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[Total: 9]

- 3 Fig. 3.1 shows a pie chart which represents the different stages of the cell cycle of an animal cell. One complete cycle takes 12 hours at 22 °C.

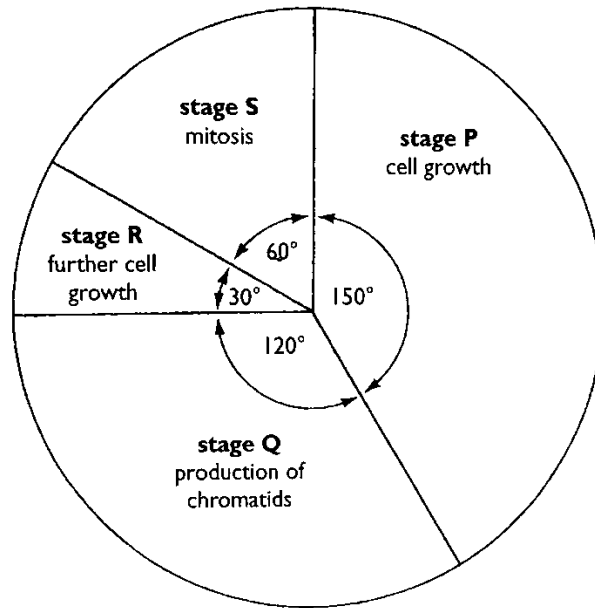


Fig. 3.1

- (a) (i) Express as a whole number ratio the total time spent on cell growth to the time spent on production of chromatids at 22 °C.

whole number ratio [1]

- (ii) Express the time spent on mitosis as a percentage of the total time required for one cycle at 22 °C. Give your answer to 3 significant figures.

time spent on mitosis.....% [1]

- (iii) The cell cycle is controlled by check points.

Identify the checkpoint between stage **P** and stage **Q** and state its function.

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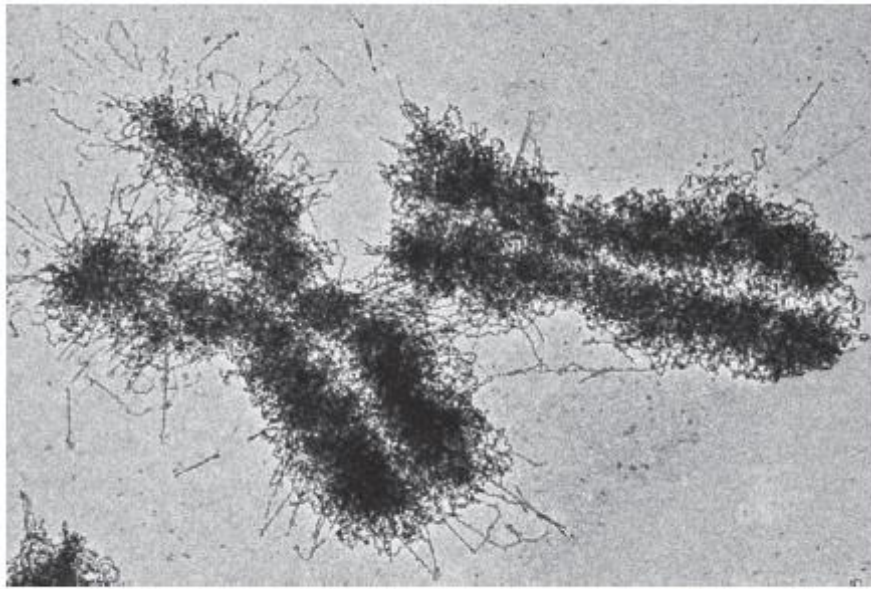
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- (b) Fig. 3.2 is a transmission electron micrograph of two human chromosomes at metaphase of mitosis, stage **S** of the cell cycle.



magnification = $\times 14\,000$

Fig. 3.2

- (i) Outline how DNA molecules are packed to form the chromosomes shown in Fig. 3.2.

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(ii) Describe what happens in the **next** stage of mitosis.

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[Total: 11]

Question 4 begins on page 11.

- 4 (a) Outline the main steps in the polymerase chain reaction that allow many copies of a DNA sequence to be produced.

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- (b) Fig 4.1 shows the alleles of two genes on chromosome 1 of two fruit flies. The female fruit fly is heterozygous for both genes A and B, whereas the male fruit fly is homozygous for both genes A and B.

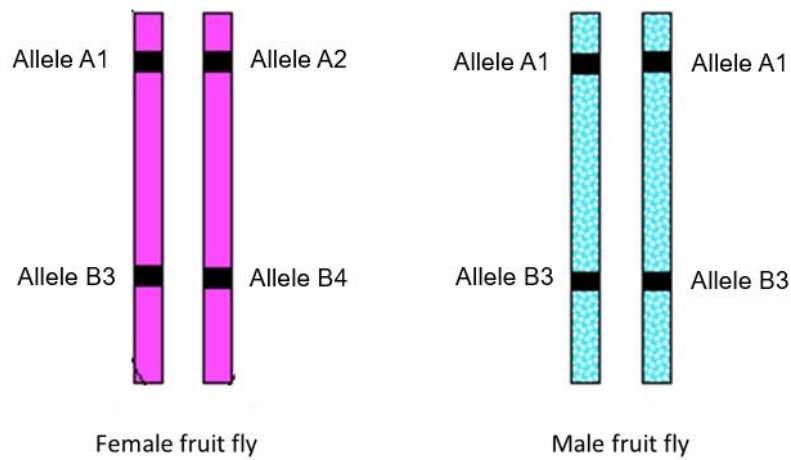


Fig. 4.1

The fruit flies were crossed and 200 progenies were produced. Using Southern Blotting, the banding patterns of the parents and progeny were visualised, as shown in Fig. 4.2.

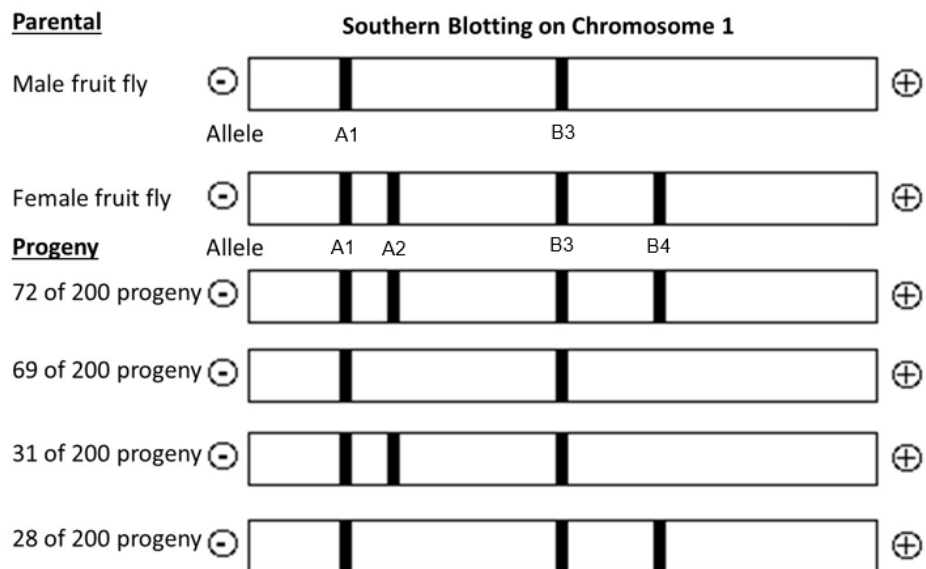


Fig. 4.2

With reference to Fig. 4.1 and Fig. 4.2,

- (i) state precisely the type of genetic inheritance observed.

..... [1]

- (ii) explain your answer in (b)(i).

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- (c) Some of the germline cells in the parental female fruit fly have been discovered to have a mutation at the centromere of chromosome 5.

Suggest how this could affect the gametes formed from these cells.

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[Total: 10]

5 Fig. 5.1 shows some molecules involved in protein synthesis.

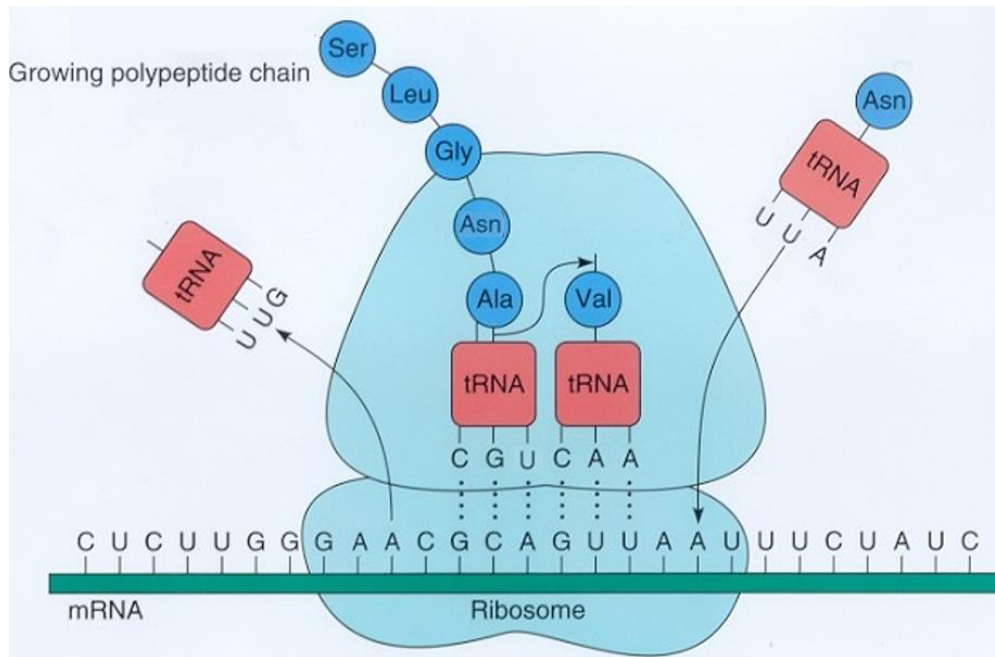


Fig. 5.1

(a) Outline how the mRNA in Fig. 5.1 is formed.

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- (b) The genetic code is a set of rules that determines how genetic information is used during protein synthesis.

Explain the features of the genetic code that are **evident in Fig. 5.1**.

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- (c) Explain the function of the large ribosomal subunit in Fig. 5.1.

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[Total: 10]

- 6 The foxglove, *Digitalis purpurea*, is a common plant in many parts of the world.

Fig. 6.1 shows a foxglove.



Fig. 6.1

Flower colour in foxgloves is controlled by two genes that interact with each other.

- Dominant allele **M** codes for an enzyme involved in the production of a purple pigment.
- Recessive allele **m** codes for a non-functioning enzyme so no purple pigment is produced, resulting in a white colour.
- Dominant allele **D** interacts with allele **M** to produce dark purple flowers.
- Recessive allele **d** does not interact with allele **M**.
- Neither allele **D** nor allele **d** interacts with allele **m**.

A double homozygous foxglove with dark purple flowers was crossed with a double homozygous recessive foxglove with white flowers. All the offspring had dark purple flowers.

- (a) Explain what is meant by the term *homozygous*.

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[1]

- (b) Using the symbols above, state the genotype of the offspring with dark purple flowers.

.....[1]

(c) Two of these offspring with dark purple flowers were crossed.

This cross produced a mixture of plants with three different flower colours:

- dark purple
- purple
- white

Draw a Punnett square to show the possible genotypes and phenotypes of the mixture of plants from this cross.

Write down the expected phenotypic ratio of plants with each flower colour.

phenotypic ratio: [4]

- (d) The foxglove plants are naturally found at the bases of mountains (sea level), up to the sub-alpine regions (about 2000 m) in Europe.

Based on the information above, explain how climate change might alter the distribution of foxglove plants.

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[Total: 9]

- 7 Fig. 7.1 shows the arrangement of the bacterial chromosome and a plasmid in a bacterial cell.

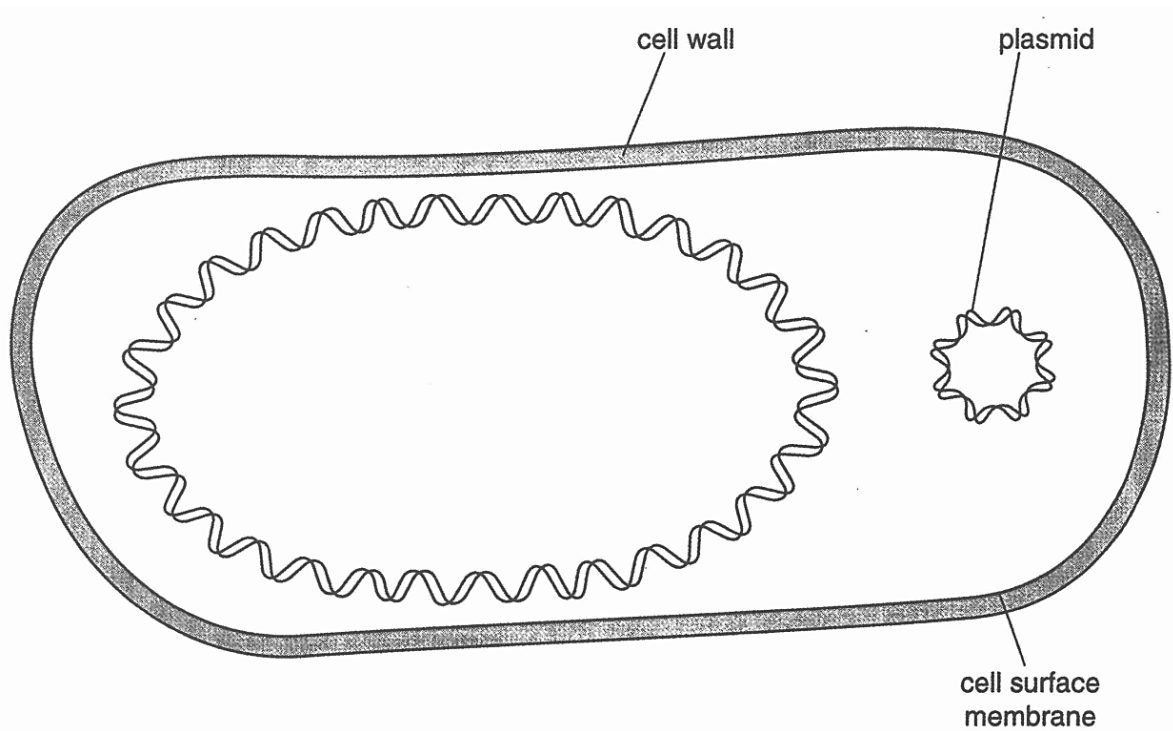


Fig. 7.1

- (a) An example of a plasmid is the F plasmid. The F plasmid is involved in conjugation.

- (i) State **two** ways in which a plasmid such as the F plasmid differs from the bacterial chromosome.

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(ii) Discuss the potential benefit of conjugation in a population of bacteria.

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(b) Genes on the bacterial chromosomes are organised into operons such as the *lac* and *trp* operons.

A fusion between the *trp* operon and the *lac* operon was created in a laboratory, resulting in the *trp-lac* fusion operon shown in Fig. 7.2.

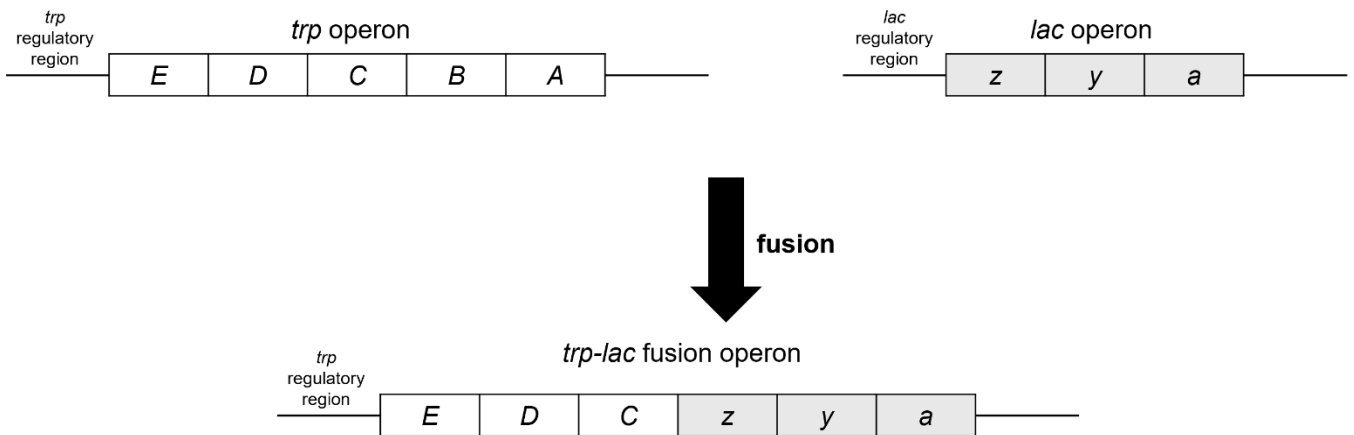


Fig. 7.2

Predict **and** explain the effect of the presence of the following molecules on the expression of β -galactosidase in the *trp-lac* fusion operon.

(i) tryptophan

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(ii) lactose

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[Total: 10]

8 Fig. 8.1 is a diagram of a mitochondrion.

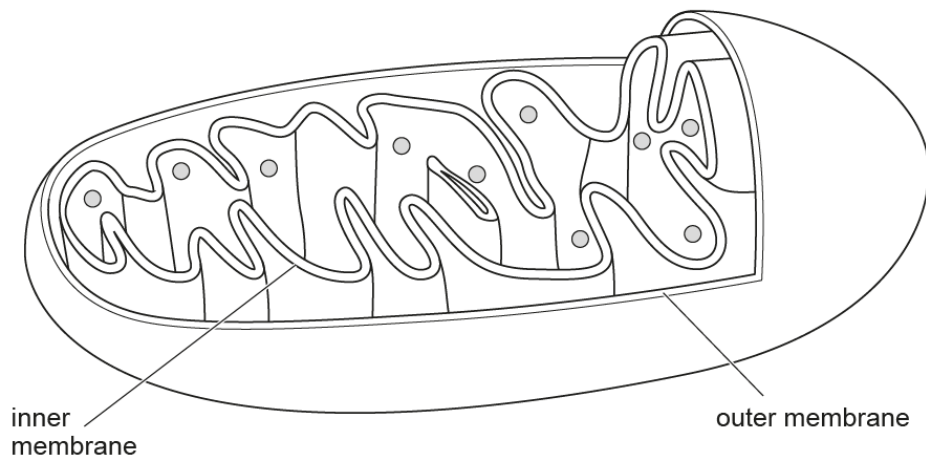


Fig. 8.1

(a) Compare the structure of the inner membrane and the outer membrane.

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(b) The shapes and numbers of mitochondria in a cell are continually changing due to fission. Fission occurs when one mitochondrion splits to form two mitochondria.

Suggest reasons why mitochondria carry out fission.

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- (c) A respirometer is a piece of apparatus that can be used to measure the rate of respiration of living tissue such as germinating peas.

A simple respirometer is shown in Fig. 8.1.

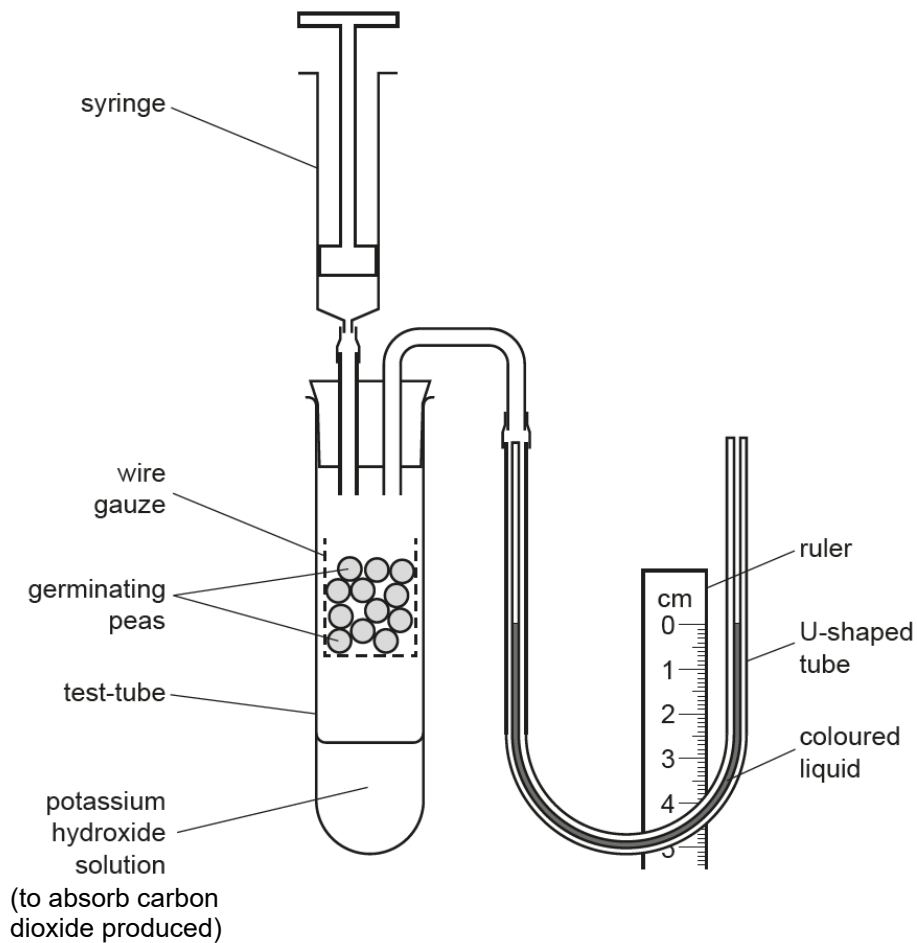


Fig. 8.1

A student carried out an investigation to determine the effect of temperature on the rate of respiration of germinating peas.

- The student set up the respirometer as shown in Fig. 8.1 and placed the respirometer in a water-bath at 10 °C.
- After five minutes, the student used the syringe to adjust the position of the coloured liquid in the right-hand side of the U-shaped tube so that it lined up with 0 cm on the ruler.
- The student immediately started a timer.
- The germinating peas used up oxygen, causing the coloured liquid in the U-shaped tube to move.
- The student measured the distance moved by the coloured liquid after 20 minutes.
- The student repeated the experiment at temperatures of 20°C, 30°C, 40°C and 50°C.

The rate of movement of the coloured liquid in the U-shaped tube, calculated from the results, is shown in Table 8.1.

Table 8.1

temperature / °C	rate of movement / mm min ⁻¹
10	0.40
20	0.70
30	1.30
40	1.15
50	0.60

- (i) Plot a graph of the results shown in Table 8.1 on the grid in Fig. 8.2.

Draw a curved line of best fit.

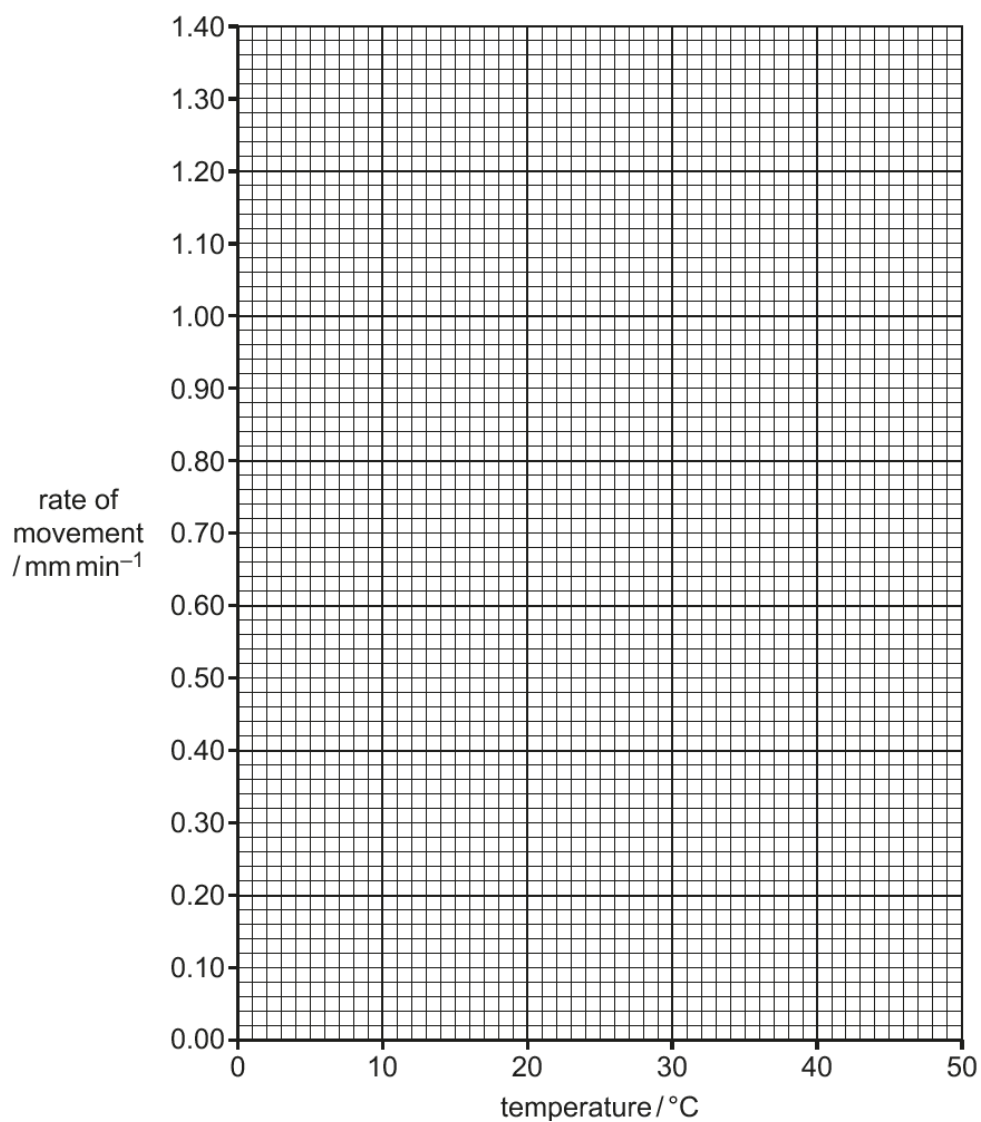


Fig. 8.2

[2]

- (ii) The rate of movement of the coloured liquid is related to the rate of respiration.

Explain the effect of temperature on the rate of respiration shown in Table 8.1 and Fig. 8.2.

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[Total: 10]

- 9 Living organisms display an incredible diversity in shape and function. To understand this diversity, biologists use classification systems and phylogeny.

(a) Explain the relationship between classification and phylogeny.

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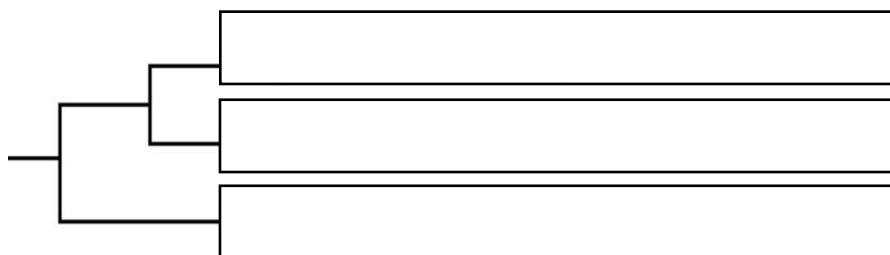
.....[2]

- (b) The percentage similarity in DNA sequences of three different species of songbirds, *Spinus spinus*, *Carduelis carduelis* and *Serinus canaria* is determined by aligning homologous regions and calculating the proportion of identical bases. The results are shown in Table 9.1.

Table 9.1

species of songbirds from which hybrid DNA was from	percentage of similarity in DNA sequences
<i>Spinus spinus</i> and <i>Carduelis carduelis</i>	95.4
<i>Carduelis carduelis</i> and <i>Serinus canaria</i>	85.7
<i>Spinus spinus</i> and <i>Serinus canaria</i>	82.3

With reference to Table 9.1, complete the figure below with names of the species of songbirds.



[1]

- (c) The songbirds inhabit the coastlines of islands throughout the Galapagos archipelago.

Fig. 9.2 maps the biogeography of the three species on the Galapagos islands, where the circles represent the proportion of the different species of songbirds on each island.

It is known that the volcanic islands of Galapagos did not emerge at the same time, but progressively over a period of three million years. The map indicates the age of each island in mya (million years ago). The nearest mainland country, Ecuador, is 900 km east of these islands.

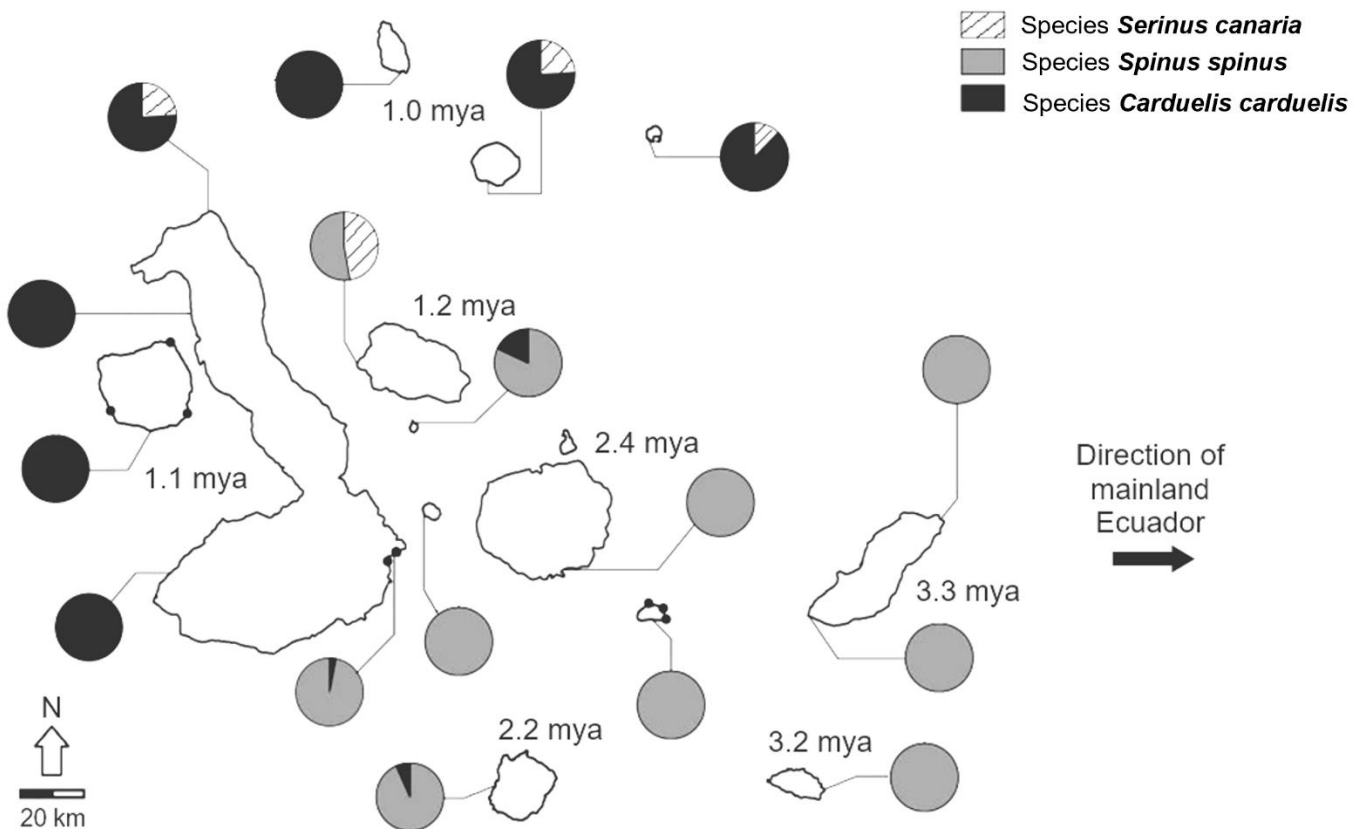


Fig. 9.2

Suggest an explanation for the biogeographical distribution of the songbirds in Fig. 9.2.

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(d) Humans are drawn to songbirds for their melodic songs.

- Directed evolution is carried out in the laboratory in which different mutations are introduced into the *FOXP2* gene (a key gene associated with the *Spinus spinus* songbird's ability to produce complex songs) to create a large number of variants of the *FOXP2* gene.
- These gene variants are then injected into the *Spinus spinus* fertilised eggs which will then grow into *Spinus spinus* adult songbirds.
- The *Spinus spinus* adult songbird with the best ability to produce complex songs will then be selected for breeding.
- These *Spinus spinus* adult songbirds also thrive on the same dandelion plant seeds diet as the wild-type *Spinus spinus*.

Using the information above and **two named** species concepts, explain why the *Spinus spinus* adult songbirds that are grown from directed evolution is considered a *Spinus spinus* sub-population and **not** a different species from the wild-type *Spinus spinus*.

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[Total: 10]

10 The El Niño phenomenon is characterised by increased temperatures in the oceans.

(a) Explain how El Niño affects coral habitats **and** food chains.

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- (b) Another impact of climate change is the global spread of dengue. Fig. 10.1 shows the worldwide distribution of dengue.

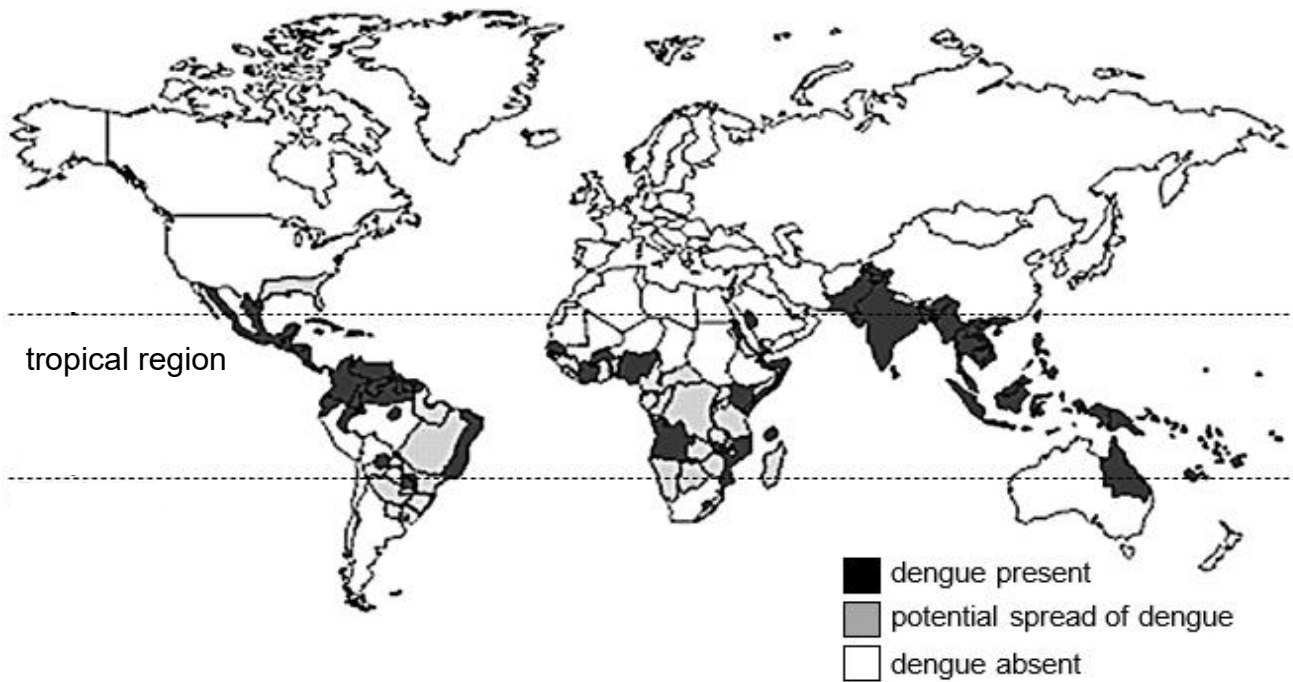


Fig. 10.1

Explain why dengue shows the distribution pattern in Fig. 10.1.

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[Total: 7]

- 11** Fig. 11.1 shows the main steps in an immune pathway involving an immune cell, which occurs during a viral infection.

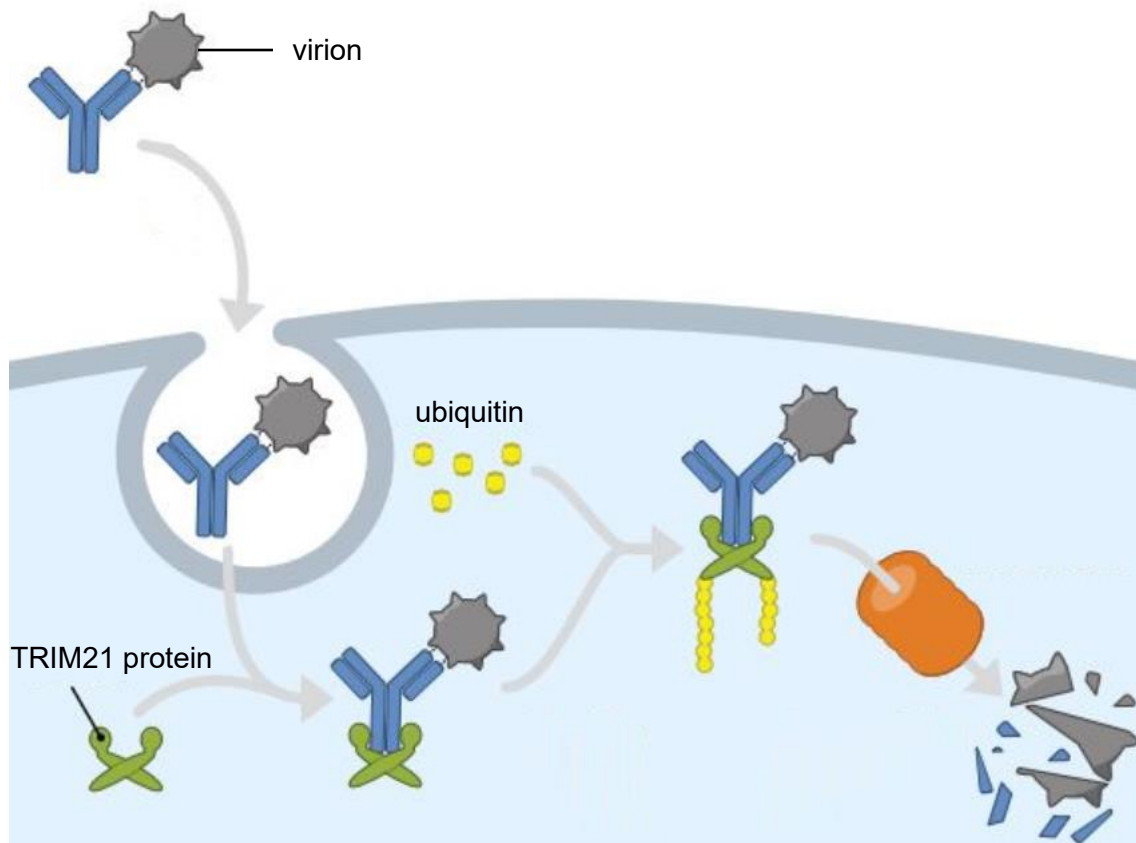


Fig. 11.1

Describe the main stages in this immune pathway, as shown in Fig. 11.1.

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[Total: 5]

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