Oxford Cambridge and RSA

Tuesday 13 May 2025 – Afternoon

GCSE (9–1) Biology B (Twenty First Century Science)

J257/03 Breadth in biology (Higher Tier)

Time allowed: 1 hour 45 minutes

You must have:
- a ruler (cm/mm)

You can use:
- a scientific or graphical calculator
- an HB pencil

H

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **32** pages.

ADVICE
- Read each question carefully before you start your answer.

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1 There are approximately 350 000 African savannah elephants.

(a) 130 000 of these elephants live in Botswana, a country in southern Africa.

Which of these is the closest approximation to the fraction of African savannah elephants that live in Botswana?

Tick (✓) **one** box.

$\frac{1}{2}$ ☐

$\frac{1}{3}$ ☐

$\frac{1}{4}$ ☐

$\frac{1}{5}$ ☐

[1]

(b) The African savannah elephant is an endangered species.

Conservation efforts have been successful in increasing the number of elephants.

Suggest **one** method that may have been used to help conserve this species.

.....

..... **[1]**

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(c) In May 2020, many elephants were found dead in a region of Botswana.

Scientists discovered that their death was caused by a bacterium that only causes disease once in the blood of an elephant.

The bacterium usually lives in the nose of some elephants where it does **not** cause disease.

Scientists think a rise in environmental temperature caused the bacteria to enter the blood of these elephants.

(i) Suggest why the scientists may be concerned about this bacterium.

.....

..... **[1]**

(ii) Which of these will ingest and digest the bacterium?

Tick (✓) **one** box.

Antibodies ☐

Platelets ☐

Red blood cells ☐

White blood cells ☐

[1]

(iii) Which of these will tag the bacterium for attack?

Tick (✓) **one** box.

Antibodies ☐

Platelets ☐

Red blood cells ☐

White blood cells ☐

[1]

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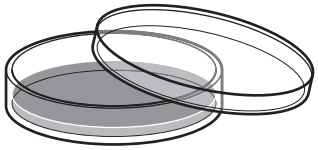
(d) To identify the type of bacterium responsible for the death of the elephants, the scientists cultured the bacteria.

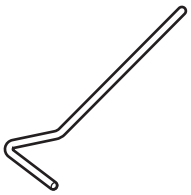
They poured some of the bacteria onto agar jelly in a Petri dish and spread it with a glass spreader.
Then they incubated the Petri dish.

The diagram shows the equipment they used.

Glass bottle containing the sample of bacteria



Petri dish containing agar jelly



Glass spreader

Suggest **two** ways the scientists could improve their method to make sure the technique was aseptic.

1 .....

.....

2 .....

.....

[2]

(e) Some bacteria have evolved to become resistant to antibiotics.

The statements describe the steps in this process.

They are **not** in the correct order.

A Bacterium survives.

B Bacterium has a selective advantage.

C Bacterium passes resistance gene to offspring.

D Bacterium reproduces.

E Mutation occurs in the DNA of a bacterium creating a gene for antibiotic resistance.

Write the letters in the boxes to show the correct order of the steps.

One of the steps has been done for you.

		A		

[2]

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(f) Bacteria evolve by natural selection.

Darwin was one of the scientists who originally developed the theory of natural selection.

Who was the **other** scientist?

..... **[1]**

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2 Yeast produce ethanol during fermentation.
A scientist investigated how temperature affects ethanol production.

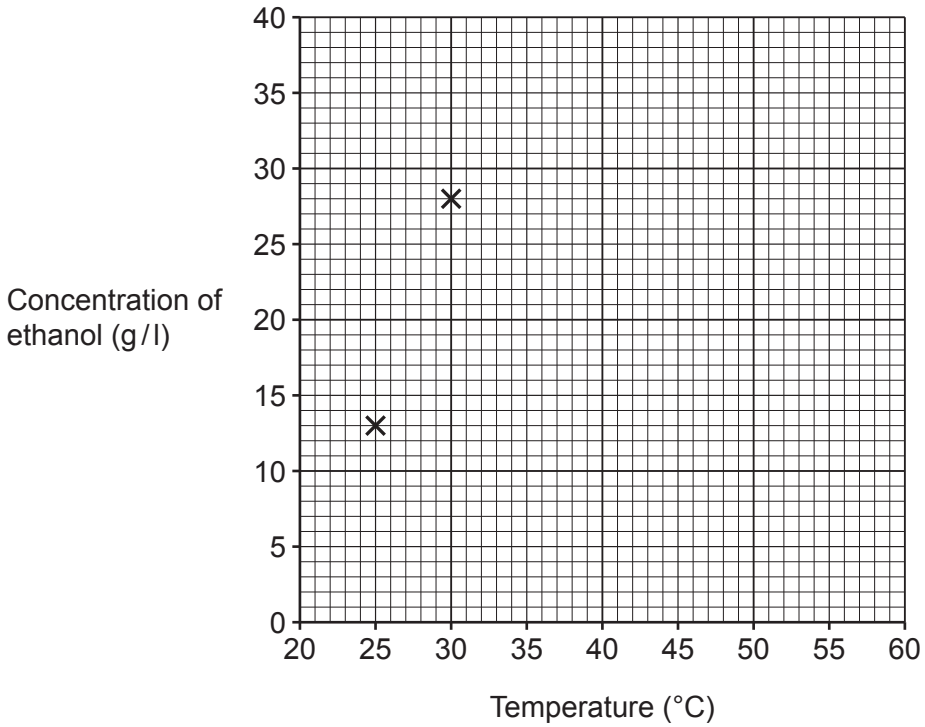
The scientist measured the concentration of ethanol in a yeast solution at six different temperatures.

The table shows their results.

Temperature (°C)	Concentration of ethanol (g / l)
25	13
30	28
35	**30**
40	**35**
45	**33**
50	**30**

(a)
(i) Plot the results from the table on the graph.

Two points have been plotted for you.



[1]

(ii) Draw a curve of best fit on the graph. **[1]**

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(b) State **two** conclusions that can be made from these data.

1 .....

.....

2 .....

.....

[2]

(c) Fermentation is another name for anaerobic respiration in yeast.

Complete the equation for **anaerobic** respiration in yeast.

sugar ⟶ ethanol + ...

[1]

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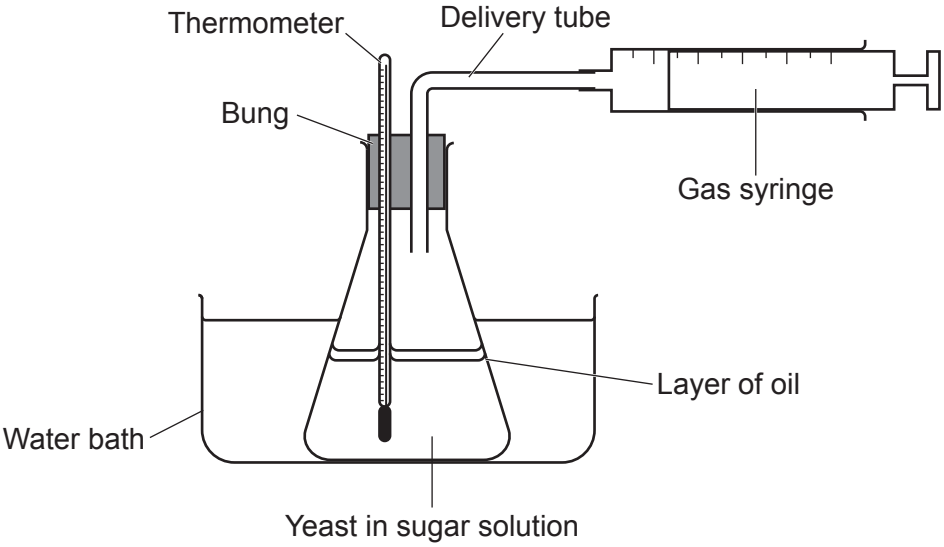
(d) The diagram shows the equipment used to investigate the effect of different sugars (sucrose, glucose and galactose) on the rate of respiration in yeast.



For this investigation, describe:
- the dependent variable
- the independent variable
- a control variable that should be kept constant.

Dependent variable .....

.....

Independent variable .....

.....

Control variable .....

.....

[3]

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Turn over for the next question

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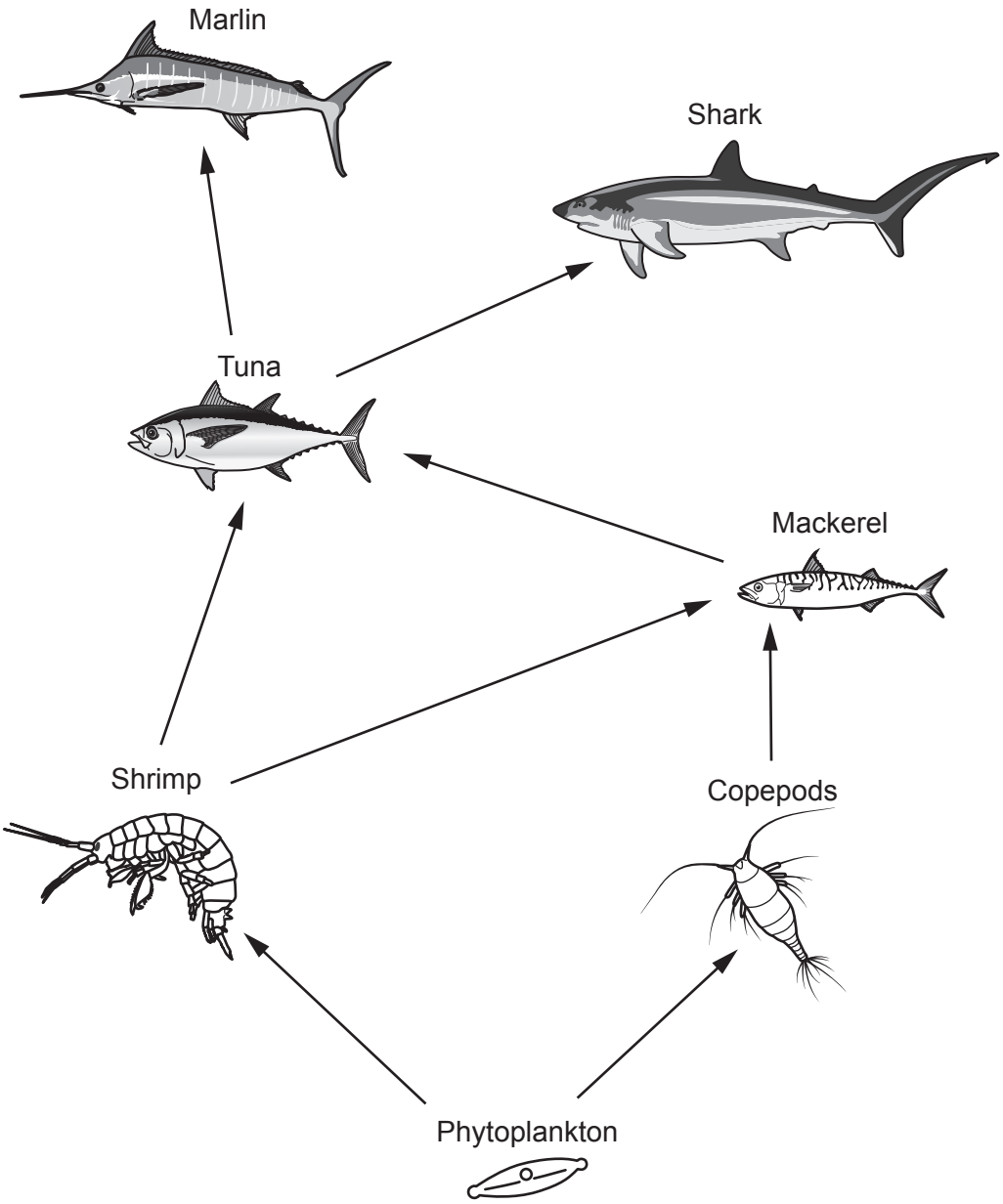
3 **Fig. 3.1** shows part of a food web for a marine ecosystem.

Fig. 3.1



(a) Name an organism in **Fig. 3.1** that feeds at two different trophic levels.

..... **[1]**

(b) Explain the possible impact on the population of **copepods** if the population of **shrimp decreased**.

.....

.....

.....

..... **[2]**

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(c) There is plenty of water and oxygen in the ocean so the shrimp do **not** need to compete for these.
The shrimp do need to compete for food.

State **one other** factor the shrimp need to compete for.

..... **[1]**

(d) Mercury is a heavy metal that can enter the water.

People are advised **not** to eat large amounts of tuna due to the quantity of mercury found in these fish.

Explain why people are advised to limit the amount of tuna eaten, but **not** the amount of mackerel.

.....

.....

.....

.....

.....

..... **[3]**

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(e) Scientists think that an increase in mercury consumption is linked to increased risk of cardiovascular disease in humans.

To investigate this, they conducted a study of 251 people.

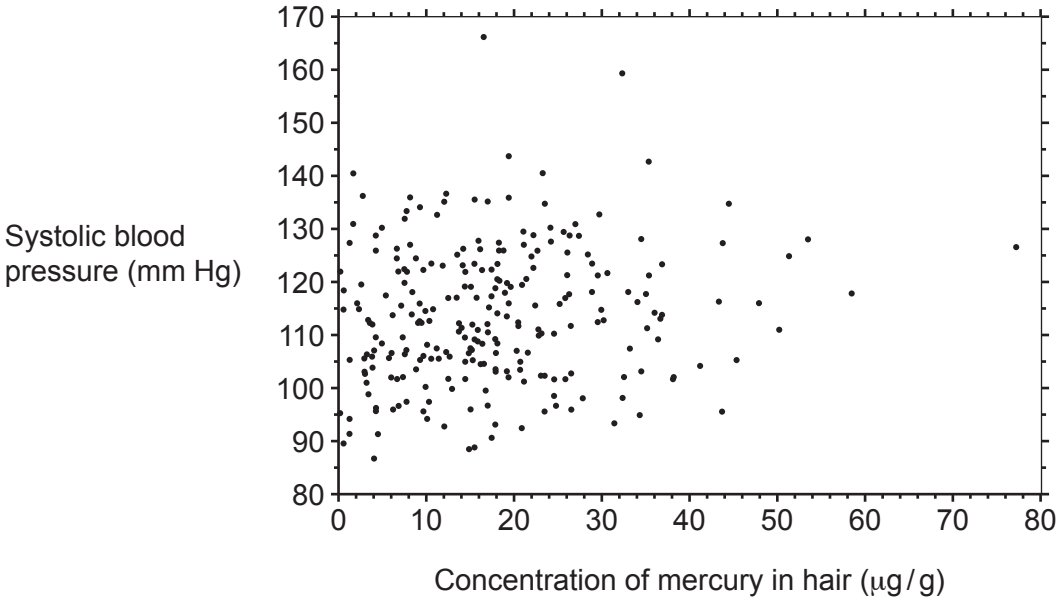
For each person they measured:
- the concentration of mercury in a strand of hair
- their systolic blood pressure.

Fig. 3.2 shows their results.

Normal systolic blood pressure is 120–129 mm Hg.

A high systolic blood pressure can be an indication of increased risk of cardiovascular disease.

Fig. 3.2



Explain why the data in **Fig. 3.2** does **not** support the link between mercury consumption and increased risk of cardiovascular disease.

.....

.....

.....

..... **[2]**

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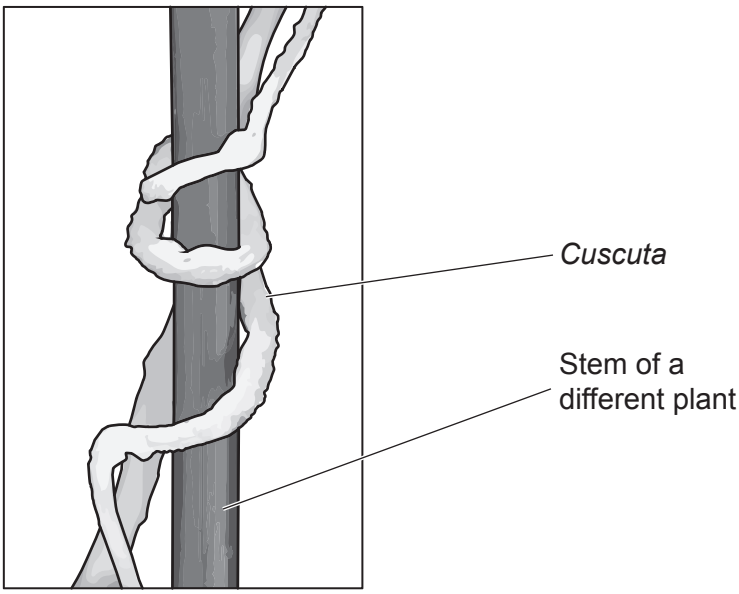
4 *Cuscuta* is a plant that does **not** have any roots or leaves. It is usually orange or yellow in colour and does **not** have chlorophyll.

Cuscuta is a parasitic plant. It wraps itself around other plants to obtain nutrients.

Fig. 4.1 shows a *Cuscuta* wrapped around the stem of a different plant.

Fig. 4.1



(a) Explain why *Cuscuta* attaches to the xylem of the plant it wraps around.

.....

..... **[1]**

(b) Explain why *Cuscuta* tries to attach to the phloem of the plant it wraps around.

.....

.....

.....

.....

.....

..... **[3]**

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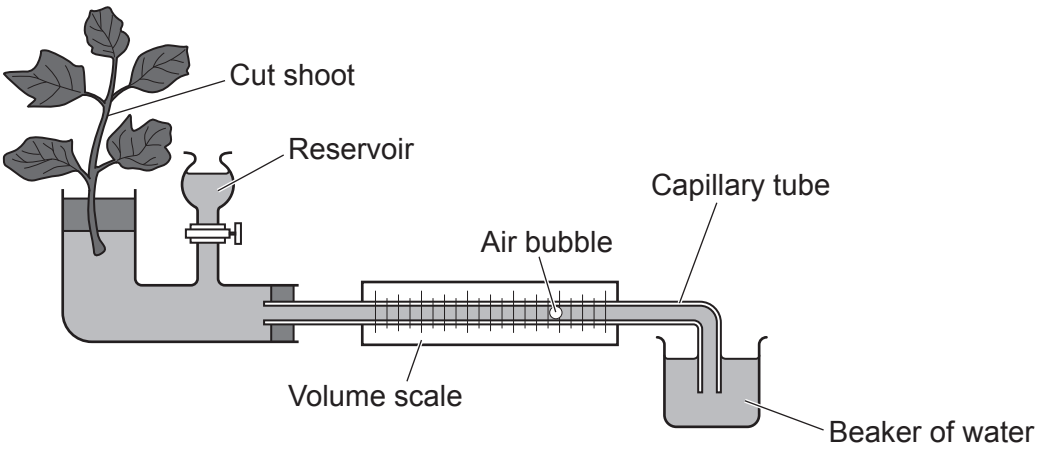
(c) Plants with leaves lose water from their leaves by transpiration.

Name the structure that allows water to move out of leaves, into the air.

..... **[1]**

(d) **Fig. 4.2** shows the apparatus used to measure the rate of water uptake from a cut shoot.

Fig. 4.2



(i) Name the apparatus shown in **Fig. 4.2**.

..... **[1]**

(ii) Which **two** measurements need to be taken to determine the rate of water uptake from the cut shoot?

1 .....

2 .....

[2]

(e) Which of these environmental factors will result in a **low transpiration rate** and which will result in a **high transpiration rate**?

Tick (✓) **one** box in each row.

	Low transpiration rate	**High transpiration rate**
High light intensity		
High windspeed		
Low temperature		

[2]

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5 Farmers use chemicals such as fertilisers and pesticides on their land.

These chemicals can affect the biodiversity of the soil and the fields.

(a) State **two** reasons why it is important to conserve biodiversity.

1 .....

.....

2 .....

.....

[2]

(b) Some farmers choose to use natural fertilisers such as animal waste.
The animal waste is broken down by decomposers which releases products such as nitrates and phosphates into the soil.

(i) Which of these describes how a plant absorbs the nitrates from the soil?

Tick (✓) **one** box.

Active transport ☐

Diffusion ☐

Osmosis ☐

Translocation ☐

[1]

(ii) Tick (✓) **one** box in each row to show whether each of these molecules are made using **nitrogen**, **phosphates**, **both** or **neither**.

	Only nitrogen	**Only phosphates**	**Both nitrogen and phosphates**	**Neither**
Glucose				
DNA				
Protein				

[2]

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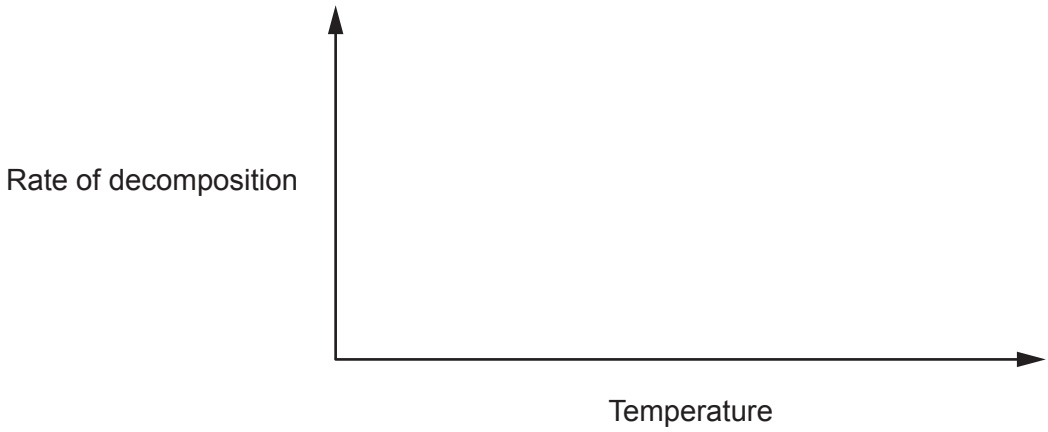
(iii) Temperature affects the rate of decomposition.

Sketch a line on the graph to show how temperature affects the rate of decomposition.



[2]

(c) An organism was found preserved in some wetlands.
The organism stopped living over 2000 years ago but had not been decomposed by microorganisms.

The wetlands the organism was found in are acidic, and the oxygen content is low.

Explain why the organism was preserved and was **not** decomposed.

.....

.....

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.....

.....

..... **[3]**

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6 The female menstrual cycle is controlled by hormones.

As a female human gets older, the levels of hormones in their body decrease.

(a) Draw lines to connect each **hormone** with its correct **function**.

Hormone	Function
FSH	Causes an egg to mature in an ovary and stimulates the ovaries to release oestrogen.
LH	Prepares the lining of the uterus for implantation of a fertilised egg.
Progesterone	Triggers ovulation.

[2]

(b) One symptom of decreasing hormone levels in female humans is hot flushes. This is a sudden increase in the temperature of the skin.

Suggest how the body tries to cool down during one of these hot flushes.

.....

.....

.....

..... **[2]**

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(c) To reduce the symptoms of decreasing hormone levels, hormone replacement therapy can be used.

Hormone replacement therapy is a medication that contains oestrogen and progesterone.

The medication can be administered by a patch which is worn on the lower part of the body. The body slowly absorbs the hormones through the skin from the patch.

(i) The patch contains 3.2 mg of an oestrogen replacement.

The absorption rate is approximately 0.5 mg in 24 hours.

Calculate the maximum number of **complete** days that the patch would release this hormone for.

Number of days = ... **[1]**

(ii) It is recommended that the patch is changed twice a week.

Suggest why this recommendation is different to the number you calculated in **(c)(i)**.

.....

..... **[1]**

(d) Before hormone replacement therapy was available as a medicine it was tested in drug trials. The first stage of this was pre-clinical trials in which the medicine was tested on cultured cells.

Describe the stages of the drug trials for hormone replacement therapy that will have happened **after** pre-clinical trials.

Explain the importance of these stages.

.....

.....

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.....

.....

..... **[3]**

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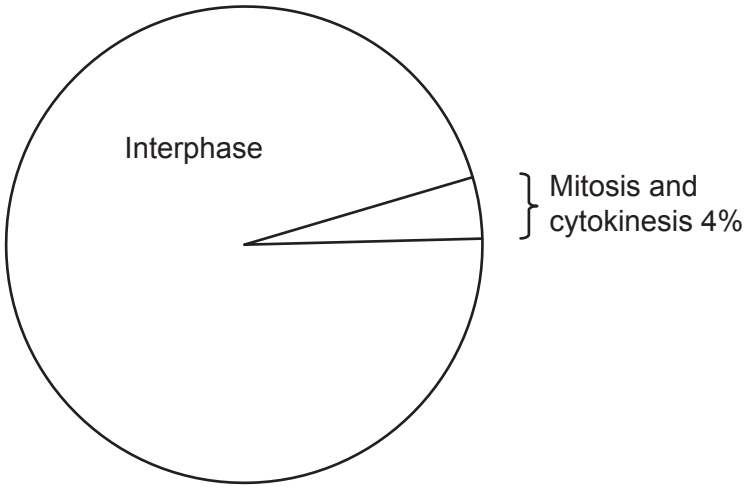
7 **Fig. 7.1** shows the cell cycle for one cell.

Fig. 7.1



(a)
(i) An intestinal cell takes 11 hours to complete the cell cycle.

Calculate the length of time that this cell is in interphase.

Give your answer:
- in **minutes**
- to the nearest **whole minute**.

Length of time the cell is in interphase = ... minutes **[3]**

(ii) Describe what happens in a cell that is in interphase.

.....

..... **[1]**

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(b) The mitotic index is a measure of the proportion of cells in a sample that are undergoing mitosis.

Table 7.2 shows data from four tissue samples analysed in a laboratory.

Table 7.2

Tissue sample	Total number of cells	Number of cells in mitosis	Mitotic index
A	750	200	0.267
B	180	110	0.611
C	188	44	0.234
D	192	28	

(i) Calculate the mitotic index for tissue sample **D**.

Use the equation: mitotic index = number of cells in mitosis ÷ total number of cells

Give your answer to **3** decimal places.

Mitotic index for tissue sample **D** = ... **[2]**

(ii) Mitotic index can be used to identify tumours. Tissue samples with a high mitotic index are more likely to be tumours.

Explain why mitotic index is used to identify tumours.

.....

.....

.....

..... **[2]**

(iii) Which tissue sample in **Table 7.2**, **A**, **B**, **C** or **D** is **most** likely to be a tumour?

..... **[1]**

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(iv) Samples taken from the centre of tumours sometimes have a lower mitotic index, whereas samples taken from the outside of tumours have a higher mitotic index.

A scientist is analysing some tumours.

Suggest how the scientist should collect and use samples from the tumours to find the mitotic index which is representative of a tumour.

.....

.....

.....

..... **[2]**

(c) Some tumours are harmful but some are **not**.

Harmful tumours usually have a higher mitotic index.

A scientist took a large number of samples from harmful tumours.
The mean mitotic index of these samples was 0.8.

A sample is taken from another tumour.
The mitotic index calculated for this tumour is 0.8.

Explain why this does **not** confirm the tumour is harmful.

.....

.....

.....

..... **[1]**

(d) Cancer is described as a non-communicable disease.

Explain why.

.....

..... **[1]**

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8 Genetic engineering is a technique used by scientists to insert a gene from the DNA of one organism or species into the DNA of another organism or species.

(a) What is a gene?

.....

..... **[1]**

(b) Scientists have genetically engineered bacteria to produce insulin.

What would the insulin produced by the bacteria be used to treat?

..... **[1]**

(c) At the beginning of the genetic engineering process, scientists insert the insulin gene into a plasmid.

Which word describes the plasmid's role in this process?

Tick (✓) **one** box.

Chromosome ☐

Genome ☐

Variant ☐

Vector ☐

[1]

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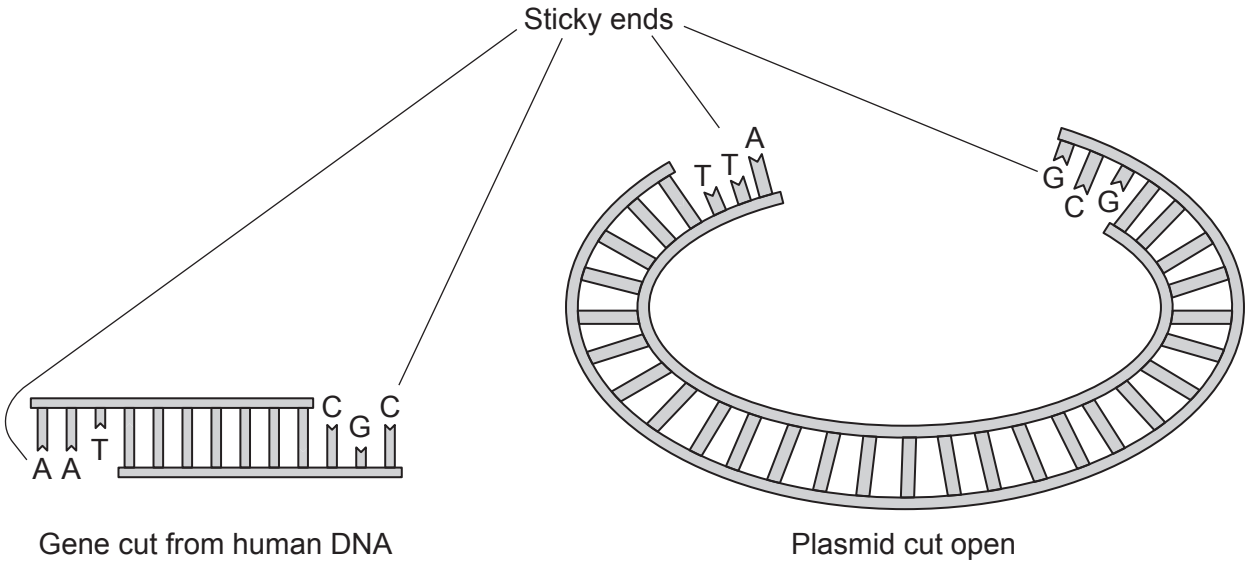
(d) The insulin gene is removed from a section of human DNA using enzymes called restriction enzymes. These enzymes cut the DNA at specific base sequences.

The plasmid is also cut open using the same restriction enzymes.

When the human DNA and the plasmid are cut, the ends have some unpaired bases. They are called 'sticky ends'. This is shown in **Fig. 8.1**.

Fig. 8.1



Explain how the creation of sticky ends enables the two sections of DNA to join.

.....

..... **[1]**

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(e) The plasmid containing the gene is inserted into the bacteria.
The bacteria divide and start producing insulin.

The bacteria are grown in large fermenters where they are provided with nutrients.

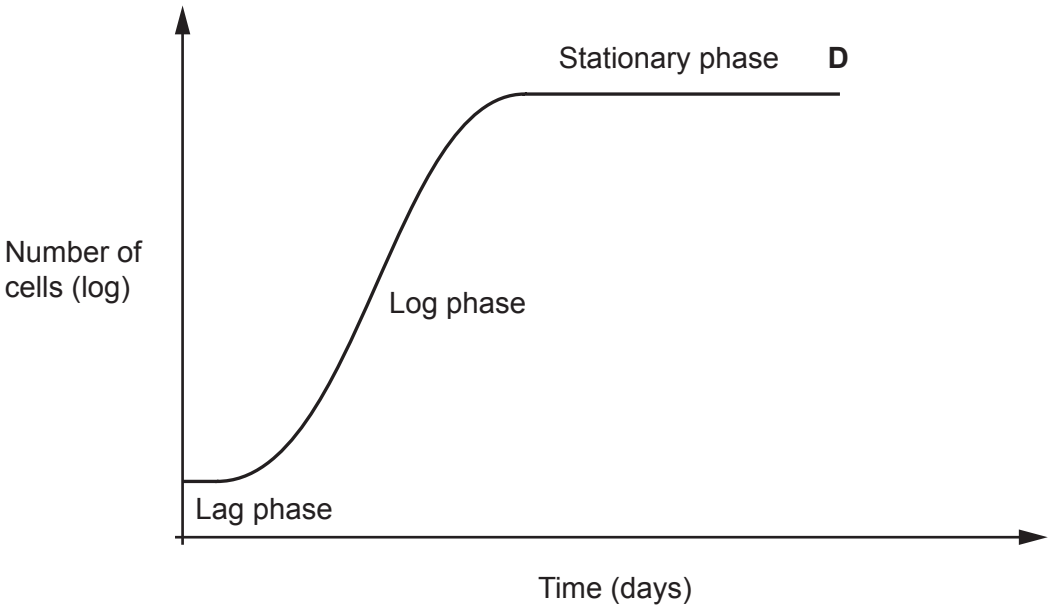
(i) The number of bacteria doubles every 20 minutes.

Calculate how many bacteria there will be after 2 hours if there are 120 at time zero.

Number of bacteria after 2 hours = ... **[2]**

(ii) **Fig. 8.2** shows the bacterial growth curve for the bacteria grown in the fermenter.

Fig. 8.2



Suggest what would happen at point **D** if the bacteria were **not** supplied with a constant supply of nutrients.

..... **[1]**

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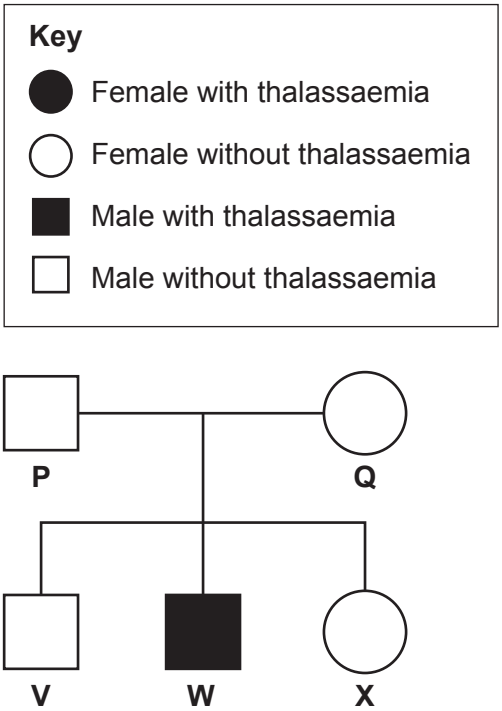
9 Thalassaemia is an inherited genetic disorder caused by a recessive allele.

(a) The diagram shows a family tree.
It includes two parents and their three children.



(i) Describe the evidence from the family tree that supports this statement:

'Thalassaemia is caused by a recessive allele.'

.....

.....

.....

.....

.....

..... **[3]**

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(ii) Individual **W** has a child with a female who is **homozygous dominant** for this genetic disorder.

Calculate the probability that this child has thalassaemia.

Probability that the child has thalassaemia = ... **[3]**

(b) Thalassaemia results in red blood cells that contain low levels of haemoglobin.

(i) What is the role of haemoglobin?

..... **[1]**

(ii) Suggest **one** symptom experienced by people with thalassaemia.

..... **[1]**

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(c) Genetic disorders are caused by DNA mutations.

(i) Complete the sentences to describe how a mutation in a gene can change the activity of an enzyme.

Use words from the list.

active site	**amino acids**	**bases**
proteins	**ribosomes**	**substrate**

The mutation changes the order of the ..... in the gene.

This changes the order of the ..... in the enzyme.

This changes the shape of the enzyme's ..... .

[3]

(ii) A mutation can also happen in non-coding DNA.

What is non-coding DNA?

Tick (✓) **one** box.

DNA that does **not** cause a genetic disorder. ☐

DNA that does **not** store instructions for making a protein. ☐

DNA that does **not** store instructions for making an enzyme. ☐

DNA that is **not** made from nucleotides. ☐

[1]

(iii) Describe how a mutation in non-coding DNA can affect an organism's phenotype.

.....

.....

.....

.....

.....

..... **[2]**

END OF QUESTION PAPER

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EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.

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