Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

3400UB0-1

S25-3400UB0-1

TUESDAY, 13 MAY 2025 – AFTERNOON

BIOLOGY – Unit 2:
Variation, Homeostasis and Micro-organisms
HIGHER TIER

1 hour 45 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**10**	
2.	**10**	
3.	**5**	
4.	**7**	
5.	**6**	
6.	**6**	
7.	**8**	
8.	**7**	
9.	**9**	
10.	**12**	
Total	**80**	

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ADDITIONAL MATERIALS

A calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

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

Question **8**(a)(ii) is a quality of extended response (QER) question where your writing skills will be assessed.

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Answer **all** questions.

1. The ability to taste the chemical phenylthiocarbamide (PTC) is controlled by a single gene called TAS2R38. The allele that allows an individual to taste PTC is dominant to the allele for non-tasting.

(a) (i) Name the **two** sense organs involved in the detection of chemicals. [1]

1. .....

2. .....

(ii) Explain the meaning of the following terms:

I. gene; [2]

.....

.....

II. allele. [1]

.....

.....

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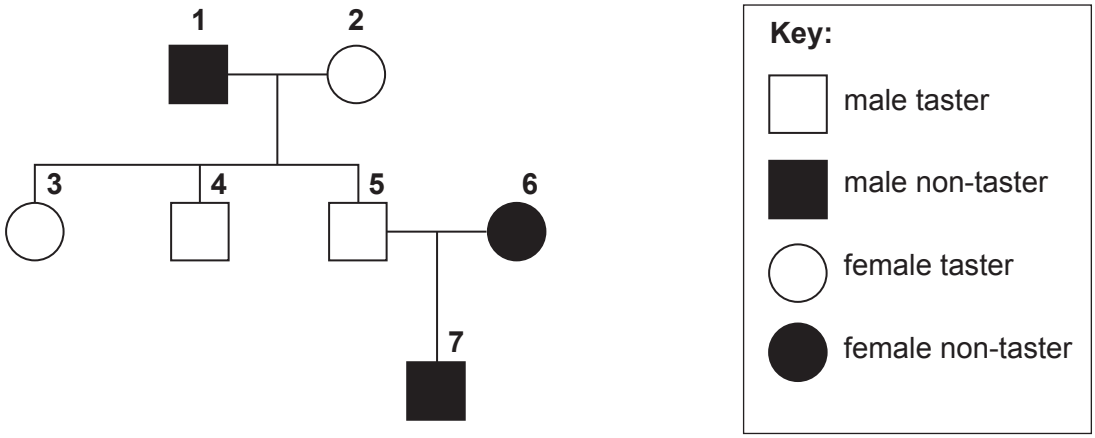
(b) **Image 1.1** is a family tree showing how the ability to taste PTC has been inherited within a family.

Image 1.1



(i) Complete the Punnett square below to show the possibility of couple **5** and **6** having a child who can taste PTC. Use the key below. [2]

key

T = allele for tasting PTC

t = allele for non-tasting PTC

(ii) **Circle a genotype** in the **Punnett square** that is **heterozygous**. [1]

(iii) Couple 5 and 6 have another child.
State the probability of this child being able to taste PTC. [1]

Probability = ...

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(c) In 1949, scientists developed a test to identify individuals who were non-tasters for PTC. They used the test to study the percentage of non-tasters in some European countries.

Table 1.2 shows the result of this test in these countries.

Table 1.2

Country	Number of individuals tested	Non-tasters (%)
Bosnia and Herzegovina	7362	32.0
Croatia	200	27.5
Czech Republic	785	32.7
Denmark	251	37.7
England	441	31.5
Hungary	436	32.2
Italy	1031	29.2
Montenegro	256	28.2
Russia	486	36.6
Slovenia	126	37.2
Spain	203	25.2

Use **Table 1.2** to state **two** reasons why the scientists can be confident in the results for PTC tasting. [2]

Reason 1

.....

.....

Reason 2

.....

.....

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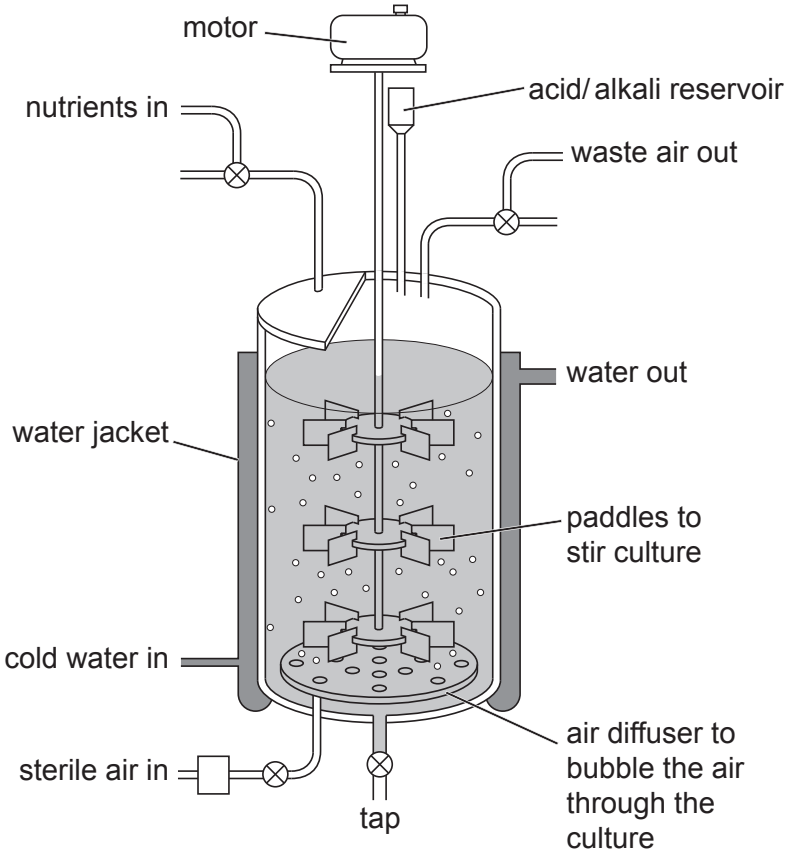
2. The antibiotic penicillin is produced from *Penicillium* grown in large stainless steel fermenters. The fermenters contain *Penicillium* in a liquid nutrient culture medium.

(a) Use the five Kingdom system of classification to state the kingdom to which *Penicillium* belongs. [1]

.....

(b) **Image 2.1** shows a diagram of a fermenter used to produce penicillin.

Image 2.1



(i) Aseptic techniques are used when *Penicillium* is added to the fermenter. State the purpose of using aseptic techniques. [1]

.....

.....

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(ii) The level of nutrients in the fermenter is controlled.
Use **Image 2.1** to state **two** other factors that need to be controlled.
Explain how each factor is controlled. [4]

Factor 1

.....

Explanation

.....

.....

Factor 2

.....

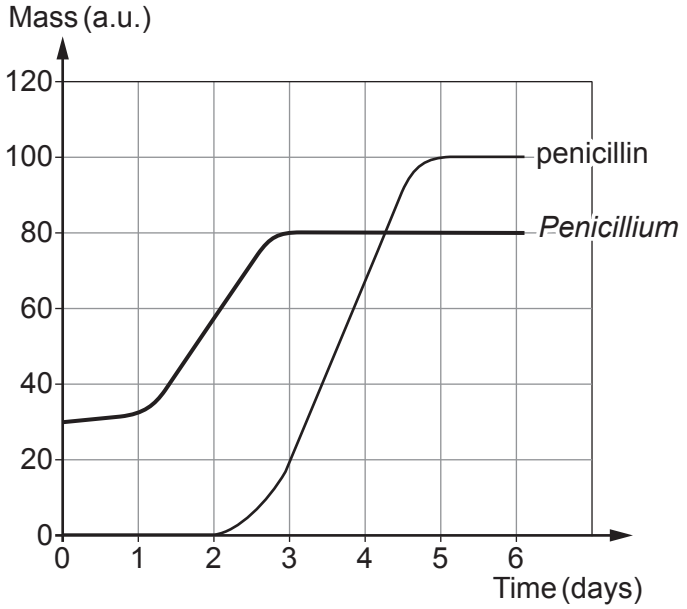
Explanation

.....

.....

(c) **Graph 2.2** shows how the contents of the fermenter changed over a period of six days.

Graph 2.2



(i) Use **Graph 2.2** to describe how the mass of ***Penicillium*** changed from **day 1 to day 6**. [2]

.....

.....

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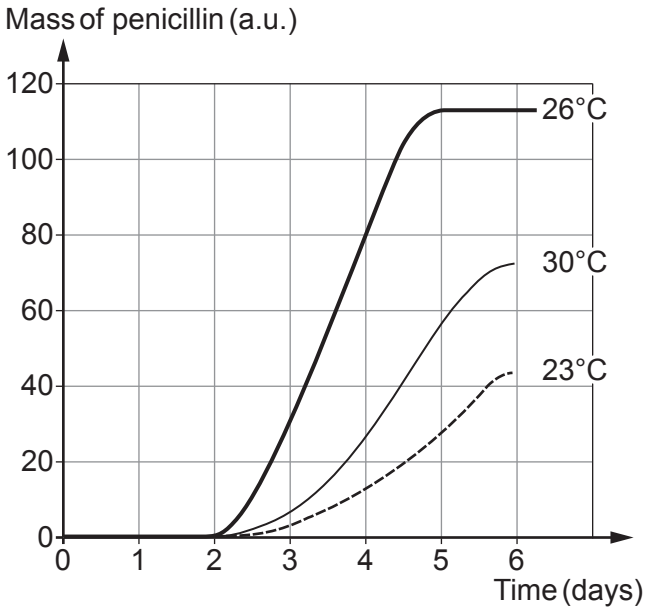
(ii) **Graph 2.3** shows the effect of different temperatures on the mass of penicillin produced over time.

Graph 2.3



Use **Graph 2.3** to suggest the optimum temperature and time for penicillin to be extracted from the fermenter. [2]

Temperature .....

Time .....

10

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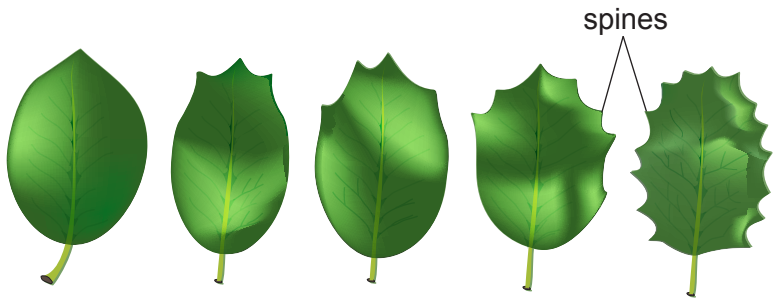
3. (a) European holly trees are an important source of food for wild animals, including rabbits and deer. **Image 3.1** shows leaves collected from the ground under one European holly tree, *Ilex aquifolium*.

Image 3.1



Students investigated variation by studying the relationship between the number of spines on a holly leaf and its height above ground.

(i) Suggest a hypothesis for this investigation. [1]

.....

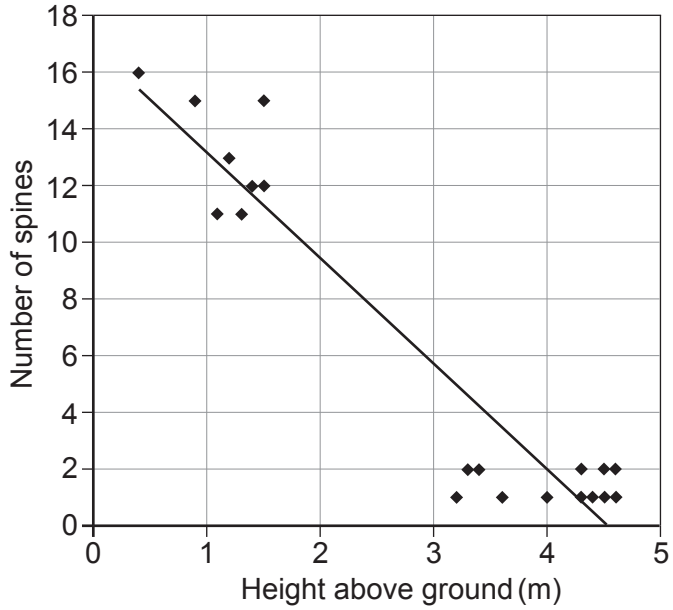
.....

The students used the following method.

1. Select one leaf at random from a holly tree.
2. Record its height above the ground.
3. Record the number of spines.
4. Repeat steps 1–3 at different heights on the same tree until the results for 20 leaves have been recorded.

Graph 3.2 shows the results from the investigation.

Graph 3.2



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(ii) I. Use **Graph 3.2** to describe the effect of height on the number of spines on a holly leaf. [1]

.....

.....

II. Suggest **one** advantage to the tree for the number of spines on leaves found at heights of 1–2 metres. [1]

.....

.....

(iii) Give **two** ways in which the strength of the evidence could be improved. [2]

I. .....

.....

II. .....

.....

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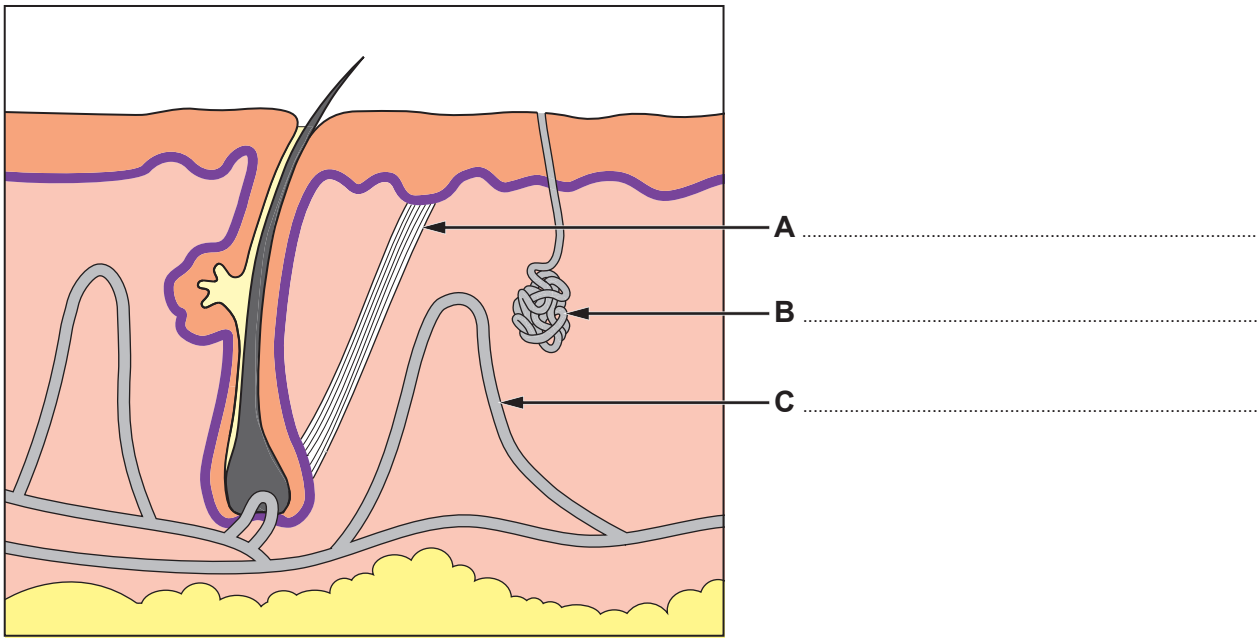
4. **Image 4.1** shows a section through human skin.

Image 4.1



(a) Label **A**, **B** and **C** on **Image 4.1**. [2]

(b) In 2022, a reporter from the BBC took part in an experiment at the University of South Wales. The aim was to investigate the effect on the body of living in cold homes.

The reporter entered a temperature controlled room set at 21 °C. The temperature in the room was reduced to 10 °C over a 30 minute time period.

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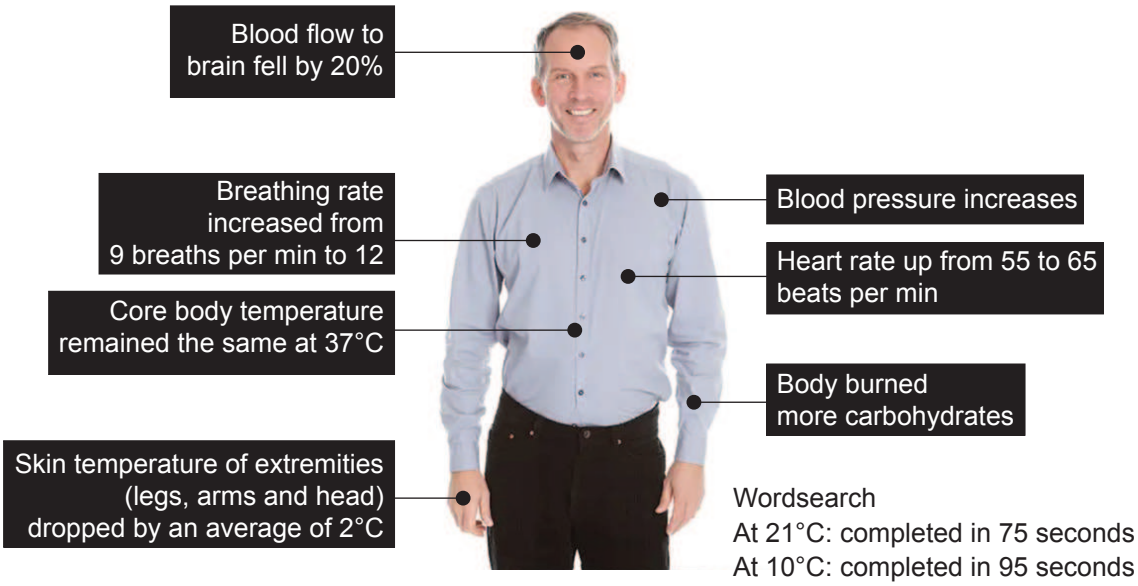
Image 4.2 shows the effect of the temperature change on his body and the time it took him to complete a wordsearch.

Image 4.2

What happened in the cold chamber?
Air temperature reduced from 21°C to 10°C for 30 minutes



(i) Describe and explain **two** changes in the skin that kept the core body temperature constant during this investigation. [4]

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(ii) Suggest why the wordsearch took longer at 10 °C than at 21 °C. [1]

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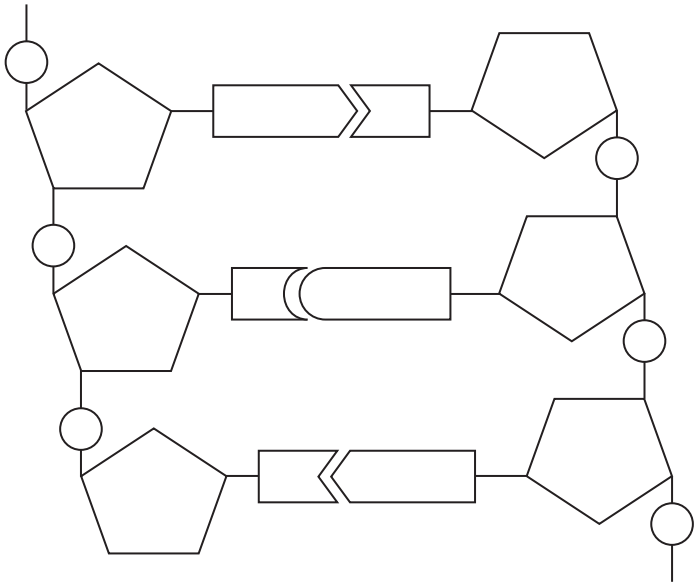
5. **Image 5.1** shows part of a DNA molecule.

Image 5.1



(a) (i) On **Image 5.1**, **draw lines to identify and label the following**: [1]

- Sugar phosphate chain
- **One** base molecule

(ii) State the name used to describe the shape of a DNA molecule. [1]

.....

(b) Sickle cell anaemia is a genetic condition. It is caused by a mutation to the gene that codes for the protein haemoglobin in red blood cells. The mutated gene produces sickle cell haemoglobin that changes the shape of red blood cells.

Images 5.2A and **5.2B** show part of the sequence of bases in the normal and mutated gene. The order of amino acids for which they code is also shown.

Image 5.2A – Normal gene

Sequence of bases	T G A		G G A		C T C		C T C
Order of amino acids	thr	–	pro	–	glu	–	glu

Image 5.2B – Mutated gene

	T G A		G G A		C A C		C T C
	thr	–	pro	–	val	–	glu

(i) **Draw a circle** on the **sequence of bases** in **Image 5.2B** to show the mutation. [1]

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(ii) Explain why the mutated gene in **Image 5.2B** gives rise to sickle cell haemoglobin protein. [3]

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6. The topshell, *Phorcus lineatus*, is a marine snail that lives along the rocky shores of parts of West Wales.
Students estimated the population density of the topshell on a rocky shore in Wales using the following method.

Method

- Use a tape measure to mark out an area of 20 m × 20 m.
- Count the number of topshells and mark their shells with a dab of paint on the underside of the shell.
- Search the same area after 1 day.
- Count the total number of topshells and the number of marked topshells found.

Image 6.1 shows a topshell.

Image 6.1

Table 6.2 shows the results of the survey.

Table 6.2

number of topshells counted in first sample	2200
number of topshells counted in second sample	2400
number of marked topshells counted in second sample	1200

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(a) (i) Use the formula below and **Table 6.2** to estimate the population of topshells in the area sampled. [2]

$$p = \frac{a \times b}{c}$$

where p = estimated size of population in sample area
a = number of topshells counted in first sample
b = number of topshells counted in second sample
c = number of marked topshells counted in second sample

Population of topshells in the area sampled = ...

(ii) Use your answer from part (a)(i) to calculate the population of topshells per m^2. [2]

Population density = ... topshells / m^2

(b) (i) State **one** assumption made when using this method to estimate the population density of topshells. [1]

.....

.....

(ii) Suggest **one** precaution that the students should take during the survey to reduce the risk of harm to topshells. [1]

.....

.....

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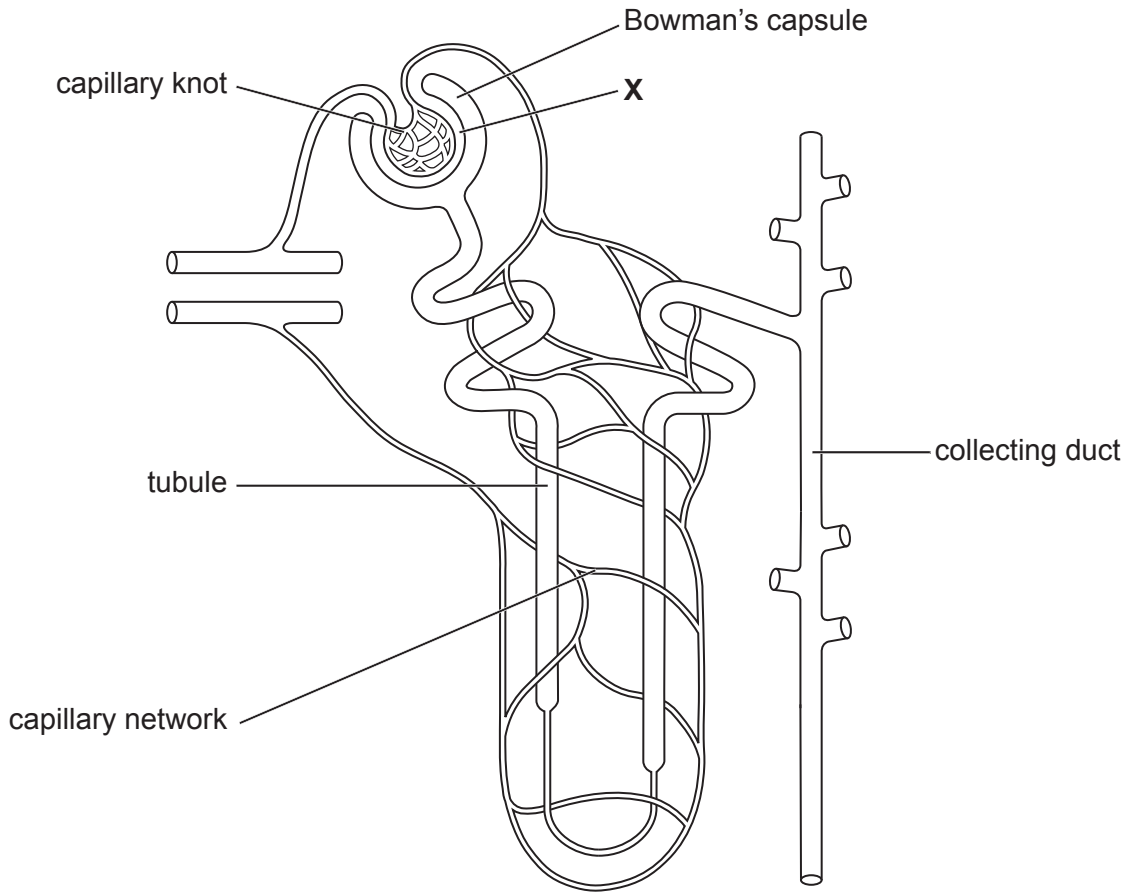
7. **Image 7.1** shows the structure of a human nephron.

Image 7.1



(a) (i) Name and describe the process occurring at point **X** on **Image 7.1**. [2]

.....

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(ii) Explain why you would not expect to find glucose present in the collecting duct. [1]

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.....

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(b) School students were provided with three samples (**A**, **B** and **C**) of artificial urine. They tested them for the presence of glucose and protein.

Table 7.2 shows the results of their tests.

Table 7.2

Sample	Glucose present	Protein present
A	×	×
B	✓	×
C	×	✓

(i) Describe the chemical tests the students would have used to test for glucose and protein. State the colour that would be observed if the substance was present.

I. Glucose [2]

.....

.....

II. Protein [1]

.....

.....

(ii) If the samples had come from the urine of hospital patients, use **Table 7.2** to suggest **one** diagnosis that could be made from the results of:

I. sample **B**; [1]

.....

II. sample **C**. [1]

.....

8

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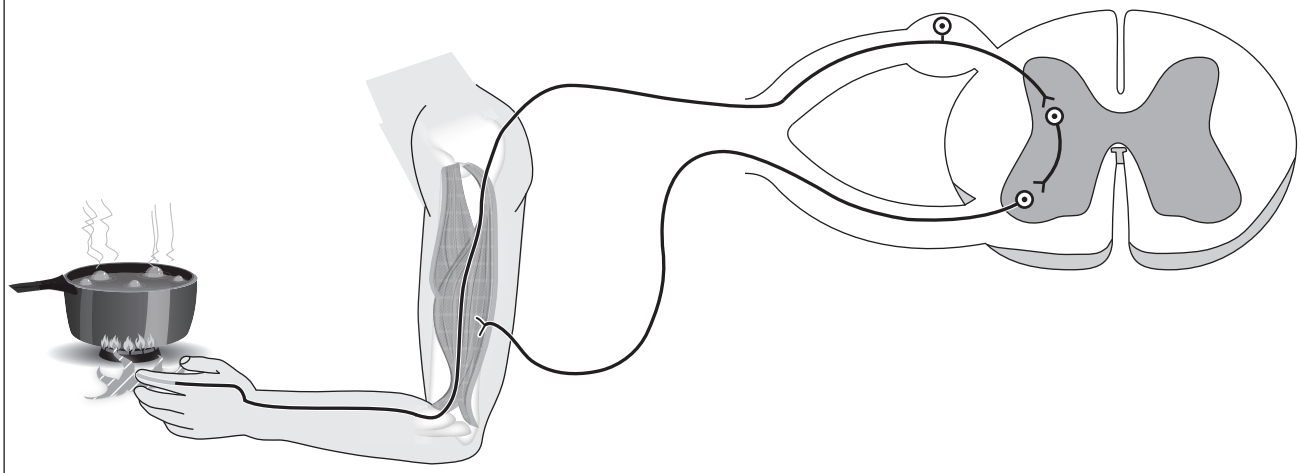
8. (a) **Image 8** shows a part of the nervous system involved in a withdrawal reflex.

Image 8



(i) Apart from being protective, state **two** other properties of a reflex action. [1]

1. .....

2. .....

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(ii) Describe the reflex arc shown in **Image 8**. [6 QER]

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9. (a) (i) State **one** type of evidence that scientists use for the classification of living organisms. [1]

.....

(ii) Apart from classification purposes, state why **scientific names** are used to identify species. [1]

.....

.....

(b) The black ant, *Lasius niger*, lives in colonies that contain a large number of female worker ants. A small number of male ants are produced when a queen ant is ready to reproduce.

Images 9.1A and **9.1B** show the production of gametes by a queen ant and a male ant. The numbers in each cell show the total number of chromosomes present.

Image 9.1A

Production of gametes (eggs) by queen ant

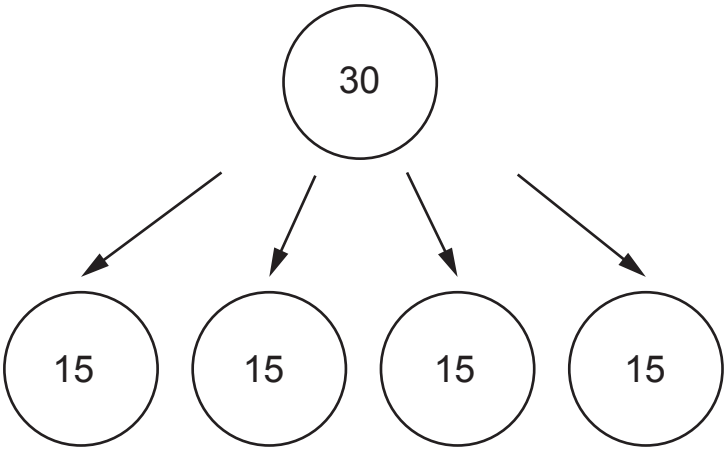
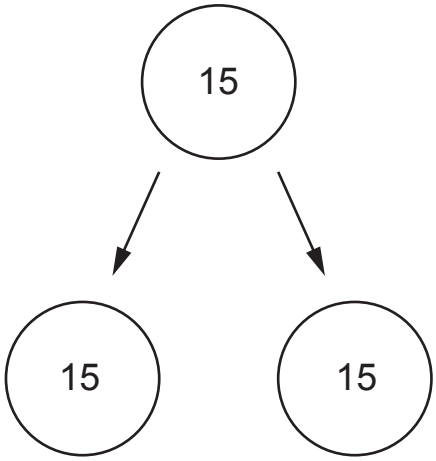


Image 9.1B

Production of gametes (sperm) by male ant



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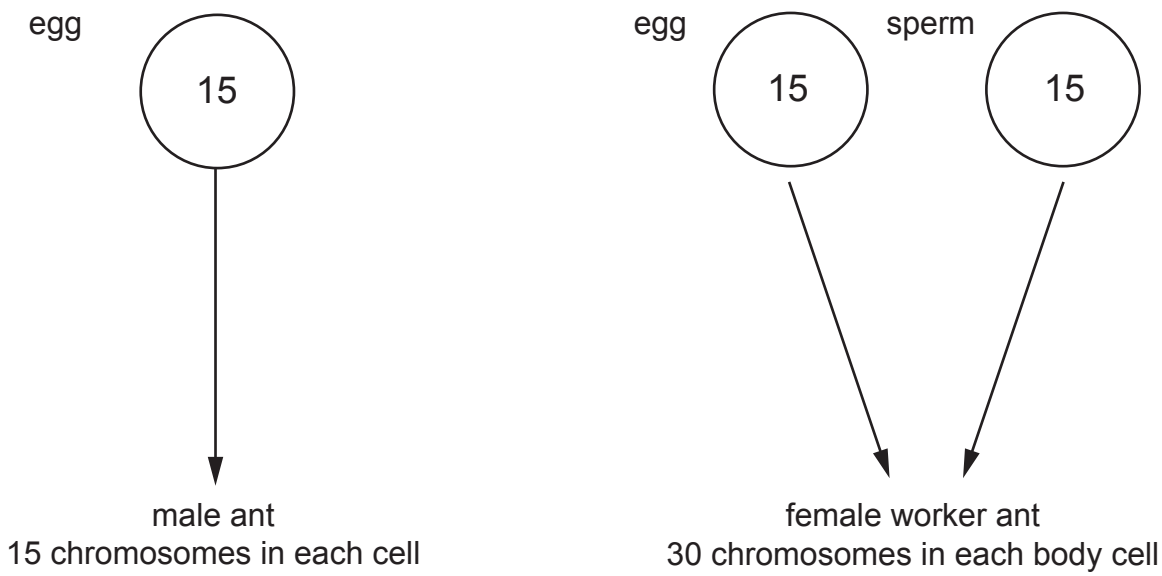
Complete **Table 9.2** to:
State the type of cell division shown in **Image 9.1A** and **Image 9.1B**.
State **one** piece of evidence for your answer. [4]

Table 9.2

	Type of cell division	Evidence
Image 9.1A	.....	....
Image 9.1B	.....	....

(c) **Image 9.3** shows how gametes from the black ant produce male and female ants.

Image 9.3



Use **Image 9.3** to explain why the body cells of a male ant contain half the number of chromosomes compared to the body cells of a female ant. [1]

.....

.....

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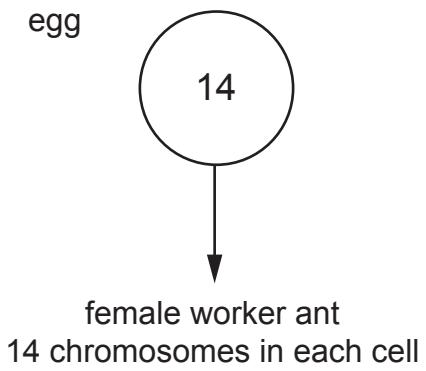
(d) A species of fungus-eating ant (*Mycocepurus smithii*) is found in Puerto Rico. It has colonies made up entirely of female ants. Most are workers and there is a small number of queen ants.

Image 9.4 shows how a gamete from *Mycocepurus smithii* produces offspring.

Image 9.4



State the type of **reproduction** shown in **Image 9.4**.
Give a reason for your answer. [2]

Type of reproduction

.....

Reason

.....

.....

9

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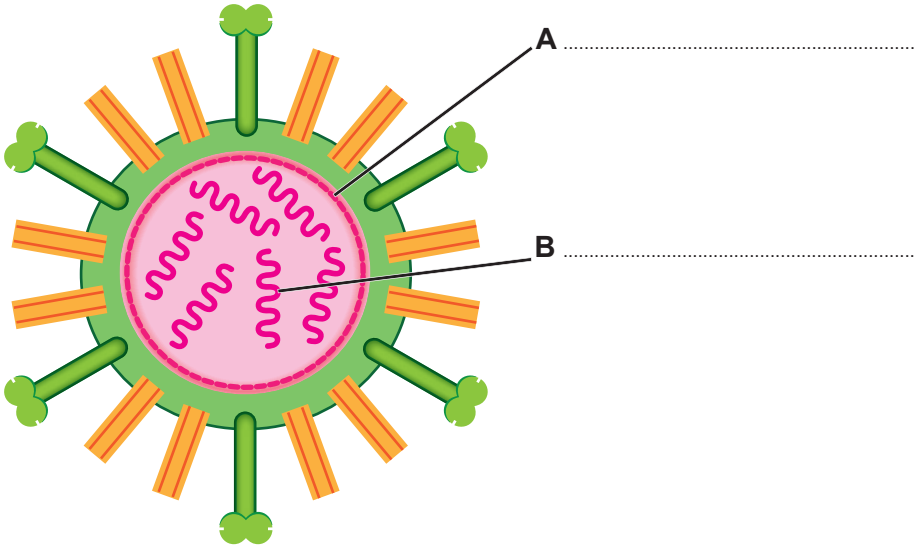
10. **Image 10.1** shows a diagram of an influenza (flu) virus.

Image 10.1



(a) Label **A** and **B** on **Image 10.1**. [2]

(b) During the last week of December 2022, there were 3800 patients in England admitted to hospital each day due to flu. This compared with 2000 each day in the previous week.

People who were feeling unwell were advised to take the following steps to avoid spreading flu or other viruses to more vulnerable people:

- stay at home
- catch coughs and sneezes in tissues that should then be disposed
- wash hands well
- wear a mask if you go out

(i) Calculate the percentage increase in the number of patients in hospital per day due to flu during the last week of December 2022. [2]

Percentage increase = ...

(ii) Explain why wearing a mask reduces the spread of flu. [1]

.....

.....

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(c) The World Health Organisation (WHO) recommends countries should target high risk groups for flu vaccinations. The WHO target is that 75% of people in all high risk groups should be vaccinated.

Table 10.2 shows vaccination rates in England in December 2022 for the high risk groups recommended by the WHO.

Table 10.2

High risk group	Vaccination rate (%)
elderly people (over 65)	77.9
children aged 6 months – 5 years	39.9
pregnant women	32.4
people with chronic disease	45.5

Use the data in **Table 10.2** to state **two** conclusions about the success of the vaccination programme in England in December 2022. [3]

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(d) (i) Explain why antibiotics are not effective against the flu virus. [1]

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.....

(ii) Describe how vaccination protects an individual against flu. [3]

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END OF PAPER

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Question number	Additional page, if required. Write the question number(s) in the left-hand margin.	Examiner only

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