Answer **all** questions in the spaces provided.

1 (a) Explain what is meant by the ecological term population.

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(1 mark)

1 (b) Four factors may affect the size of a human population. They are

- Birth rate (**B**)
- Death rate (**D**)
- Emigration rate (**E**)
- Immigration rate (**I**).

Use all the letters **B**, **D**, **E** and **I** to write a formula showing

1 (b) (i) a population that stays the same size

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(1 mark)

1 (b) (ii) a population that is increasing in size.

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(1 mark)

1 (c) The table shows some features relating to the human population of Mexico in 2007.

Feature	
Total population / millions	107
Birth rate per 1000 population	20
Death rate per 1000 population	5
Life expectancy / years	76

1 (c) (i) In 1990 the life expectancy was 70 years. Suggest **one** reason for the change in life expectancy since 1990.

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(1 mark)

1 (c) (ii) Use the information in the table to calculate the size of the population of Mexico in 2008. Show your working.

Answer ....

(2 marks)

6

Turn over for the next question

Turn over ▶

2 (a) (i) Explain what is meant by a **recessive** allele.

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(1 mark)

2 (a) (ii) Explain what is meant by **codominant** alleles.

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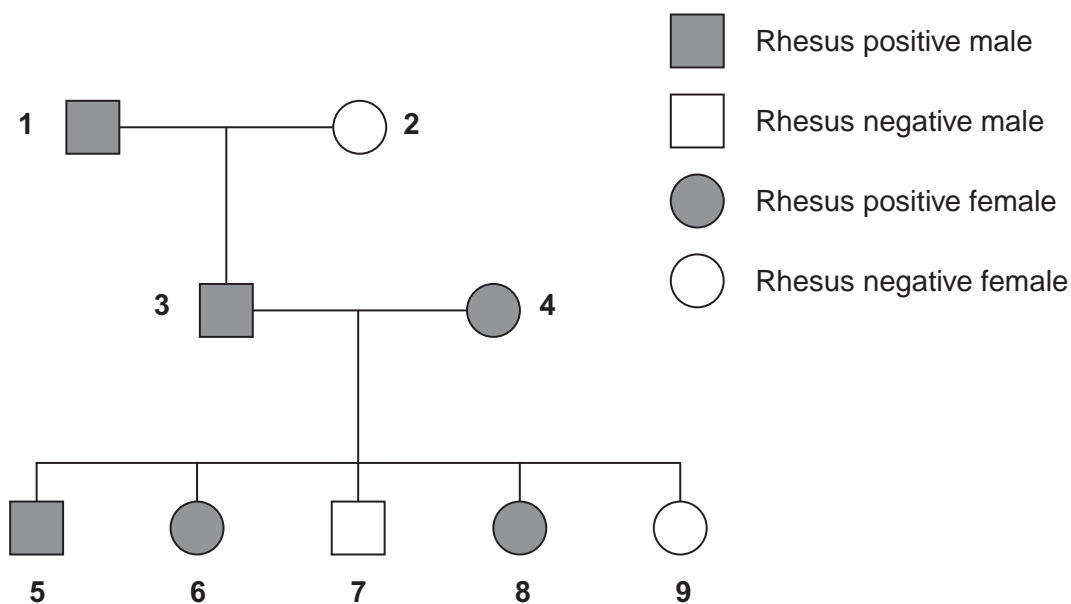
(1 mark)

2 (b) The Rhesus blood group is genetically controlled. The gene for the Rhesus blood group has two alleles. The allele for Rhesus positive, **R**, is dominant to that for Rhesus negative, **r**. The diagram shows the inheritance of the Rhesus blood group in one family.

3

Do not write outside the box

2 (b) (i) Explain **one** piece of evidence from the diagram which shows that the allele for Rhesus positive is dominant.

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(2 marks)

2 (b) (ii) Explain **one** piece of evidence from the diagram which shows that the gene is **not** on the X chromosome.

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(2 marks)

2 (c) Sixteen percent of the population of Europe is Rhesus negative. Use the Hardy-Weinberg equation to calculate the percentage of this population that you would expect to be heterozygous for the Rhesus gene.
Show your working.

Answer ....
(3 marks)

9

Turn over ▶

QUESTION 3: N/A

4   The young of frogs and toads are called tadpoles. Ecologists investigated the effect of predation on three species of tadpole. They set up four artificial pond communities. Each community contained

* 200 spadefoot toad tadpoles
* 300 spring peeper frog tadpoles
* 300 southern toad tadpoles.

The ecologists then added a different number of newts to each pond. Newts are predators. **Figure 1** shows the effect of increasing the number of newts on the percentage survival of the tadpoles of each species.

Figure 1
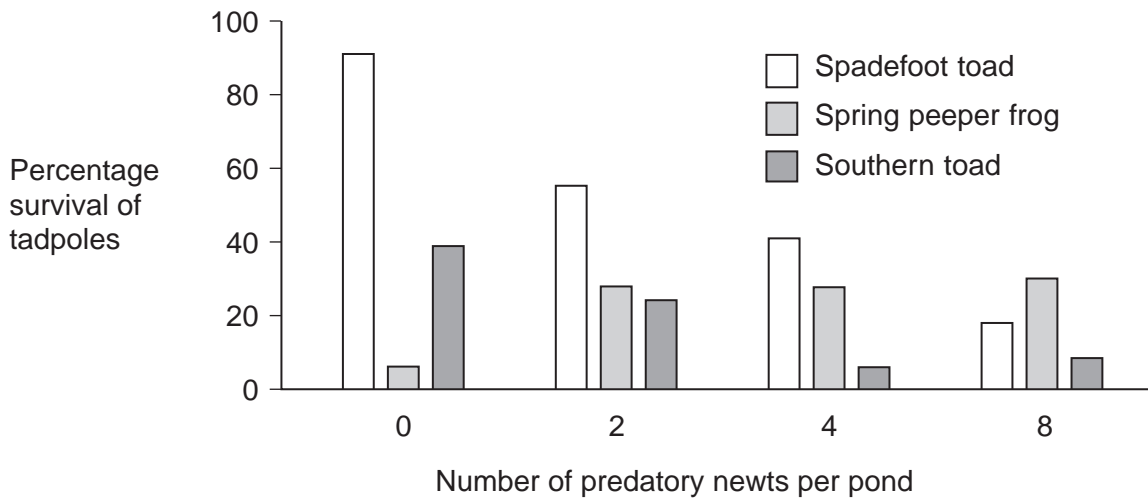
4 (a) (i)   Describe the effect of an increase in the number of newts on the percentage survival of the tadpoles of each of the **toad** species.

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(2 marks)

6

4 (a) (ii) Suggest an explanation for the effect of an increase in the number of newts on the percentage survival of the tadpoles of spring peeper frogs.

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(2 marks)

Figure 2 shows how the masses of the tadpoles were affected in each pond during the investigation.
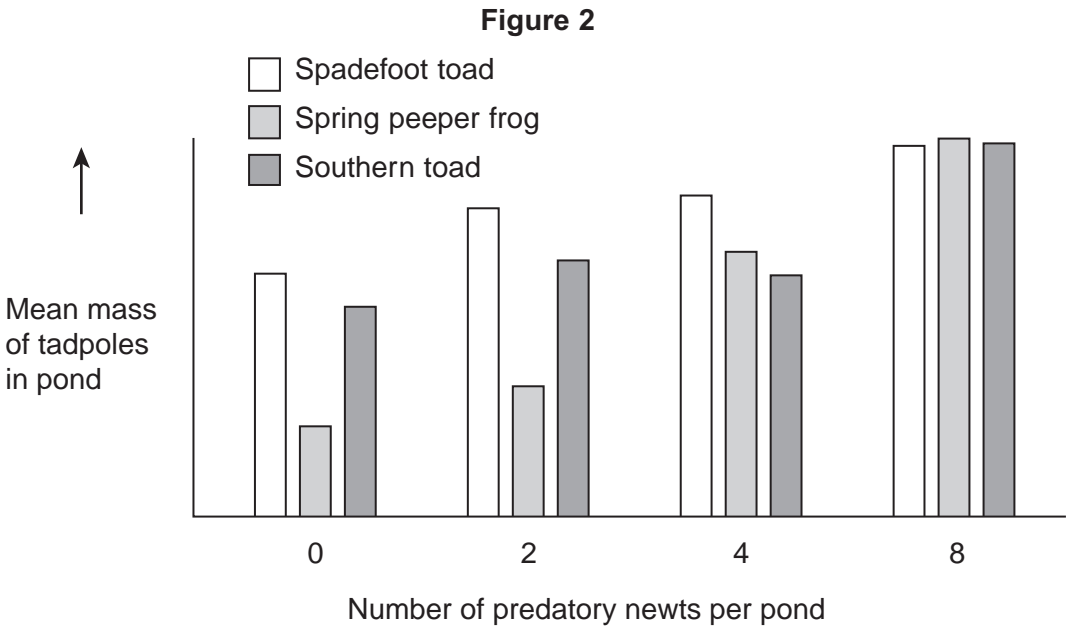
Figure 2

4 (b) Using the information provided in **Figure 1** explain the results obtained in **Figure 2**.

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(2 marks)

6

Turn over ▶

5 Haemophilia is a genetic condition in which blood fails to clot. Factor IX is a protein used to treat haemophilia. Sheep can be genetically engineered to produce Factor IX in the milk produced by their mammary glands. The diagram shows the stages involved in this process.

Stage **1**

Gene for Factor IX is cut
from human DNA

Stage **2**

Jellyfish gene is attached to
the human gene

Stage **3**

Promoter DNA from
sheep is attached

Stage **4**

Copies of this DNA are
inserted into the nuclei of
body cells from sheep

Stage **5**

Each nucleus is
transplanted into a sheep
egg cell from which the
original nucleus has
been removed

Stage **6**

The egg cells divide to form
an embryo. Each embryo is
implanted into the uterus
of a different sheep

5 (a)   Name the type of enzyme that is used to cut the gene for Factor IX from human DNA (Stage **1**) .

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(1 mark)

5 (b) (i)   The jellyfish gene attached to the human Factor IX gene (Stage **2**) codes for a protein that glows green under fluorescent light. Explain the purpose of attaching this gene.

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(2 marks)

5 (b) (ii) The promoter DNA from sheep (Stage **3**) causes transcription of genes coding for proteins found in sheep milk.

Suggest the advantage of using this promoter DNA.

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(2 marks)

(Extra space) ....

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Question 5 continues on the next page

Turn over ▶

5 (c)   Many attempts to produce transgenic animals have failed. Very few live births result from the many embryos that are implanted.

5 (c) (i)   Suggest **one** reason why very few live births result from the many embryos that are implanted.

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(2 marks)

(Extra space) ....

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5 (c) (ii)   It is important that scientists still report the results from failed attempts to produce transgenic animals. Explain why.

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(2 marks)

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Question 6: N/A

7   Residual food intake (RFI) is the difference between the amount of food an animal actually eats and its expected food intake based on its size and growth rate. Scientists have selectively bred cattle for low RFI.

7 (a) (i)   Explain the advantage to farmers of having cattle with a low RFI.

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(2 marks)

7 (a) (ii)   When RFI is calculated, low values are negative. Explain why they are negative.

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(1 mark)

7 (b)   Scientists have developed a standard procedure for comparing RFI in cattle. They control **two** factors. These are type of food and environmental temperature. Explain why each of these factors needs to be controlled.

Type of food

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Environmental temperature

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(4 marks)

7 (c) Bacteria in the digestive systems of cattle break down food and produce methane. Scientists investigated the relationship between RFI and methane production. They measured the rate of methane production of 76 cattle over a fifteen-day period. Some of the results are shown in **Figure 3**.

Figure 3

	Low RFI	**High RFI**
Mean rate of methane production / g day^{-1}	142.3	190.2

7 (c) (i) Suggest a null hypothesis for this investigation.

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(1 mark)

7 (c) (ii) Selectively breeding cattle with a low RFI may help to limit global warming. Use the information in **Figure 3** to explain how.

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(2 marks)

Question 7 continues on the next page

Turn over ▶

7 (d) Other scientists investigated the release of methane from rice fields. They investigated the effect of adding organic material (straw) and inorganic substances on the release of methane from rice fields. The results are shown in **Figure 4**.

Figure 4

Inorganic substance added to soil	Total methane released over 30 days / µmol kg⁻¹ soil	
	Without straw	**With straw**
None	1179	25 492
Nitrate	63	764
Sulfate	19	144
Iron oxide	39	313
Manganese oxide	53	475

7 (d) (i) Which treatment is most effective in reducing release of methane from rice fields?

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(1 mark)

7 (d) (ii) Research findings are not always of direct use to farmers. What else would rice farmers need to know before acting on the results of this investigation?

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(2 marks)

7 (d) (iii) Methane is produced by anaerobic microorganisms in the soil. The scientists found that rice fields that are not flooded do not produce large amounts of methane. Suggest why.

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(2 marks)

15

8 (a) Succession occurs in natural ecosystems. Describe and explain how succession occurs.

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(Extra space) ....

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continues on the next page

Turn over ▶

8 (b)   Managed ecosystems such as wheat fields are prone to pest infestations. Describe the advantages and disadvantages of using biological agents to control pests.

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(5 marks)

(Extra space) ....

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8 (c) Changes in ecosystems can lead to speciation. In Southern California 10 000 years ago a number of interconnecting lakes contained a single species of pupfish. Increasing temperatures caused evaporation and the formation of separate, smaller lakes and streams. This led to the formation of a number of different species of pupfish. Explain how these different species evolved.

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(5 marks)

(Extra space) ....

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9 Huntington's disease is a genetic condition that leads to a loss in brain function. The gene involved contains a section of DNA with many repeats of the base sequence CAG. The number of these repeats determines whether or not an allele of this gene will cause Huntington's disease.

- An allele with 40 or more CAG repeats will cause Huntington's disease.
- An allele with 36 – 39 CAG repeats may cause Huntington's disease.
- An allele with fewer than 36 CAG repeats will not cause Huntington's disease.

The graph shows the age at which a sample of patients with Huntington's disease first developed symptoms and the number of CAG repeats in the allele causing Huntington's disease in each patient.

Age at which patients with Huntington's disease first developed symptoms / years

Number of CAG repeats
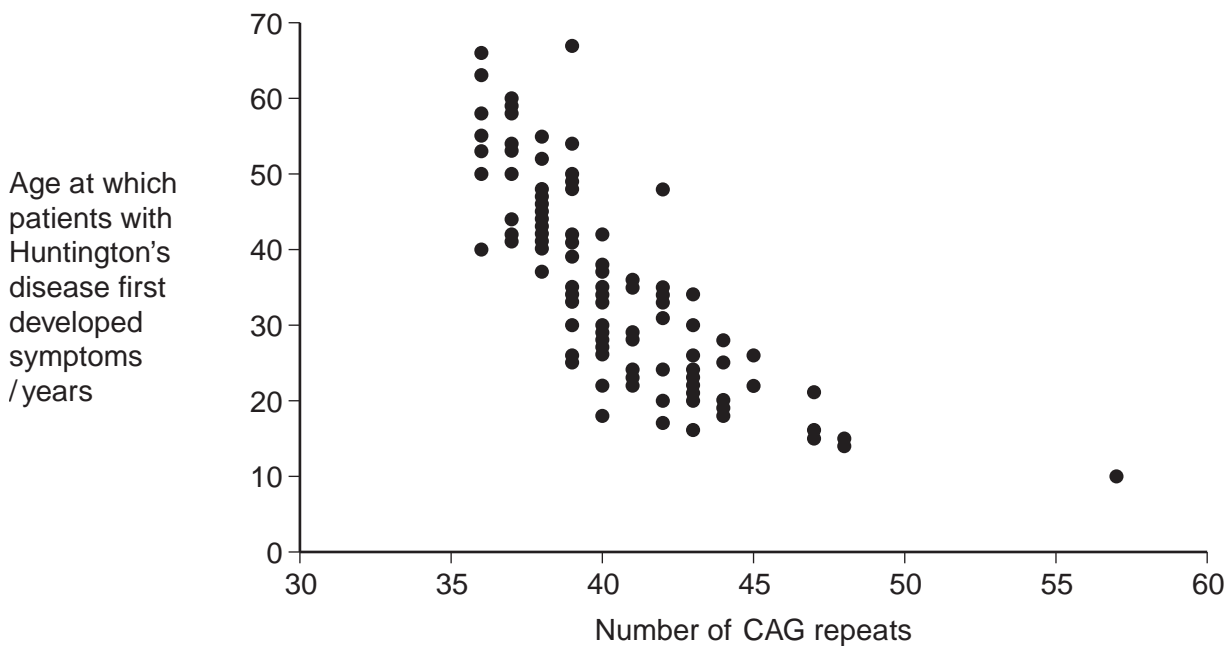
9 (a) (i) People can be tested to see whether they have an allele for this gene with more than 36 CAG repeats. Some doctors suggest that the results can be used to predict the age at which someone will develop Huntington's disease.

Use information in the graph to evaluate this suggestion.

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(3 marks)

(Extra space) ....

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(a) (ii) Huntington's disease is always fatal. Despite this, the allele is passed on in human populations. Use information in the graph to suggest why.

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(2 marks)

Question 8 continues on the next page

Turn over ▶

9 (b) Scientists took DNA samples from three people, **J**, **K** and **L**. They used the polymerase chain reaction (PCR) to produce many copies of the piece of DNA containing the CAG repeats obtained from each person. They separated the DNA fragments by gel electrophoresis. A radioactively labelled probe was then used to detect the fragments. The diagram shows the appearance of part of the gel after an X-ray was taken. The bands show the DNA fragments that contain the CAG repeats.
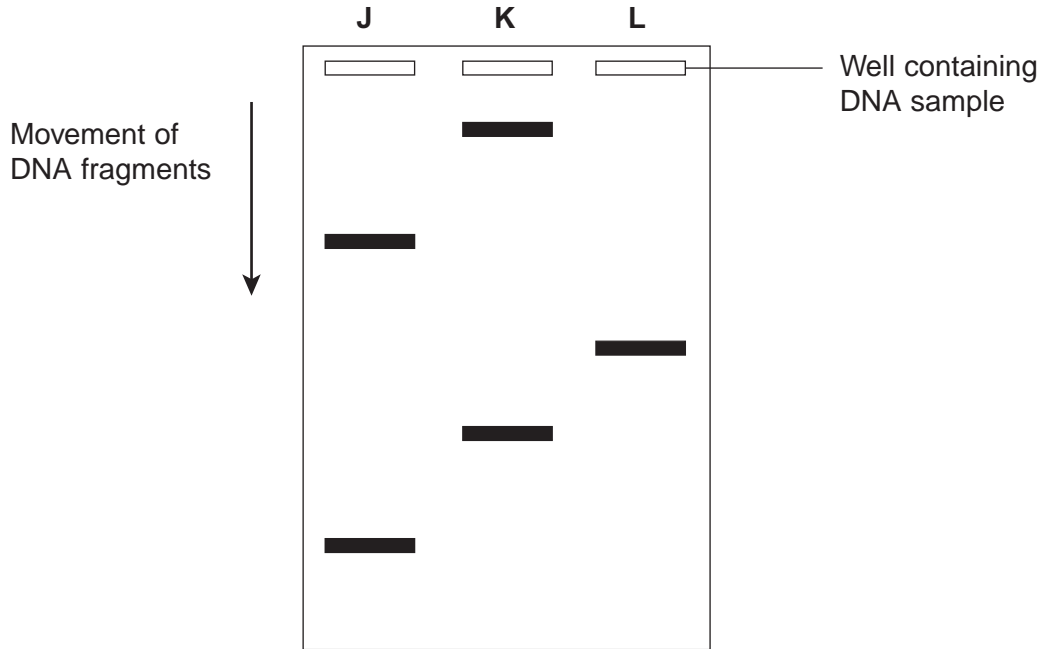
(b) (i) Only one of these people tested positive for Huntington's disease. Which person was this? Explain your answer.

Person ....

Explanation ....

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(2 marks)

9 **(b) (ii)** The diagram only shows part of the gel. Suggest how the scientists found the number of CAG repeats in the bands shown on the gel.

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(1 mark)

(b) (iii) Two bands are usually seen for each person tested. Suggest why only one band was seen for Person **L**.

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(1 mark)

9

Turn over for the next question

Turn over ▶

10   Cows suffer from heat stress when the environmental temperature is too high. Heat
stress occurs when their core body temperature rises above 39.4 °C. The table shows
how environmental temperature affects the food intake, water intake and milk
production of cows in a fixed period of time.

Environmental temperature / °C	Food intake / kg	Water intake / dm³	Milk production / dm³
20	18.2	81.8	27.0
25	17.7	88.6	25.0
30	17.0	95.0	22.9
35	16.7	144.1	18.0

(a)   Calculate the percentage decrease in milk production between the temperatures of
30 °C and 35 °C. Show your working.

Answer .... %

(2 marks)

(b)   Suggest how each of the following responses helps to maintain core body temperature.

(b) (i)   The change in water intake as environmental temperature increases.

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(1 mark)

(b) (ii) The change in food intake as environmental temperature decreases.

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(2 marks)

10 (c)　Explain the change in milk production as environmental temperature increases.

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(1 mark)

(d)　The rectal temperatures of cows are recorded to monitor heat stress. This is a better measurement of core body temperature than measuring the temperature of the skin. Explain why.

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(2 marks)

(e)　Selective breeding can be used to produce cows with desirable features. This involves mating cows with bulls. Suggest how a bull is selected to increase the probability of producing cows with a high milk yield.

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(1 mark)

continues on the next page

Turn over ▶

Milk contains lactose. Human babies produce the enzyme lactase, which digests lactose. Many human adults do not produce lactase and are lactose intolerant.

People who are lactose intolerant can become very ill if they drink milk or eat dairy products, such as butter and cheese.

(f) Scientists have recorded the percentage of adults who are lactose intolerant in different countries. Explain the advantage of using percentages in this type of study.

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(2 marks)

(g) The scientists found that the percentage of people who can tolerate lactose is much higher in populations that drink a lot of milk and eat a lot of dairy products.

Use your knowledge of natural selection to explain this finding.

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(4 marks)

(Extra space) ....

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15

Essay

You should write your essay in continuous prose.

Your essay will be marked for its scientific accuracy.

It will also be marked for your selection of relevant material from different parts of the specification and for the quality of your written communication.

The maximum number of marks that can be awarded is

Scientific content	16
Breadth of knowledge	3
Relevance	3
Quality of written communication	3

11   Write an essay on **one** of the following topics.

EITHER

(a)   The importance of shapes fitting together in cells and organisms.

(25 marks)

OR

(b)   How bacteria can affect the lives of humans and other organisms.

(25 marks)

If you want to make a plan write it here.

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