National
Qualifications
2017

X707/76/02

Biology
Section 1 — Questions

TUESDAY, 23 MAY
9:00 AM – 11:30 AM

Instructions for the completion of Section 1 are given on *Page 02* of your question and answer booklet X707/76/01.

Record your answers on the answer grid on *Page 03* of your question and answer booklet.

Before leaving the examination room you must give your question and answer booklet to the Invigilator; if you do not, you may lose all the marks for this paper.

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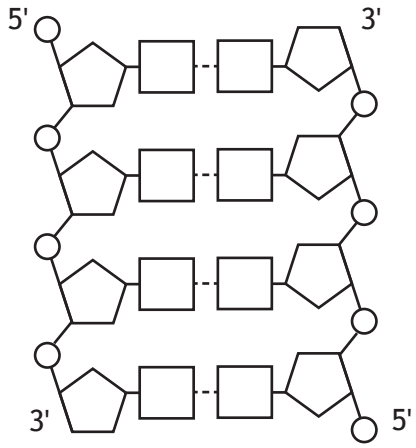
SECTION 1 — 20 marks

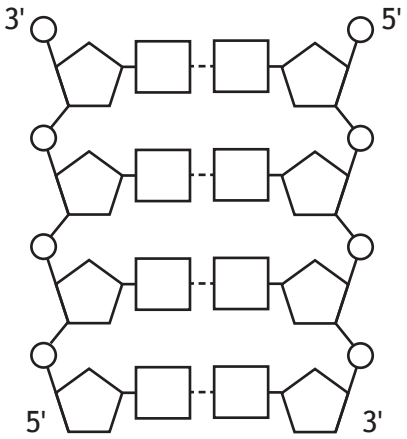
Attempt ALL questions

1. Which of the following diagrams shows the correct structure of DNA?

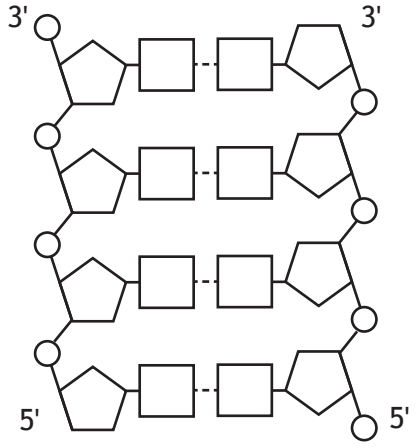
A



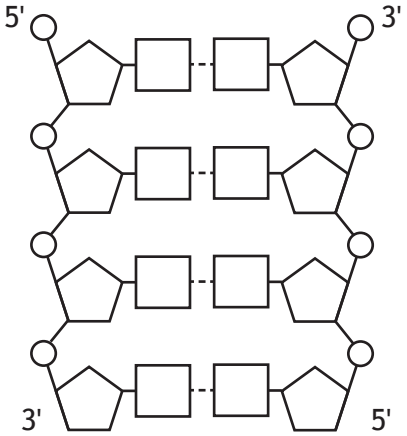
B



C



D



2. A section of double stranded DNA was found to have 60 guanine bases and 30 adenine bases.

What is the total number of deoxyribose sugars in this section?

A 30

B 90

C 180

D 270

3. The following terms describe different structures into which DNA can be organised within cells.

1 Linear chromosome

2 Circular chromosome

3 Circular plasmid

Which of these terms describe how DNA is organised within photosynthetic plant cells?

A 1 only

B 2 only

C 1 and 2 only

D 2 and 3 only

4. Which of the following molecules are required in the replication of the lagging strand of a DNA molecule?

A DNA polymerase and ligase only

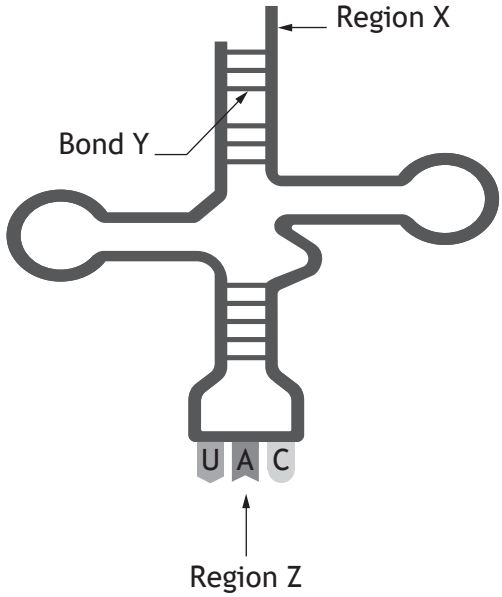
B DNA polymerase and primers only

C Ligase and primers only

D DNA polymerase, ligase and primers

[Turn over

5. The diagram shows a molecule of tRNA.



Which row in the table identifies Region X, Bond Y and Region Z?

	Region X	*Bond Y*	*Region Z*
A	amino acid attachment site	hydrogen	anticodon
B	anticodon	hydrogen	amino acid attachment site
C	amino acid attachment site	peptide	anticodon
D	anticodon	peptide	amino acid attachment site

6. New species have evolved when two populations have become

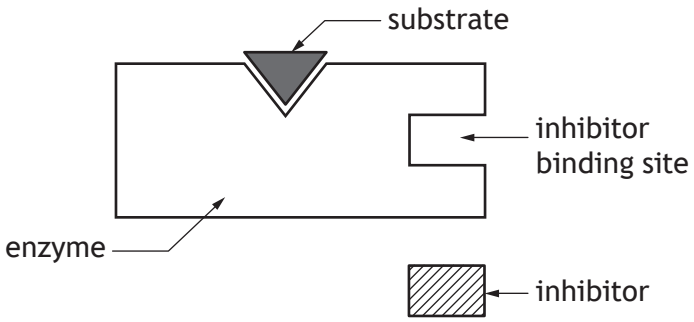
A isolated by a behavioural barrier

B unable to interbreed to produce fertile offspring

C very different due to directional selection

D very different due to disruptive selection.

7. The diagram shows an enzyme, its substrate and a substance which inhibits it.



The following statements describe some features of enzyme inhibition.

1 The inhibitor binds to the active site.

2 The effect of the inhibitor is reduced by increasing the substrate concentration.

3 The inhibitor is non-competitive.

Which of these statements apply to the inhibitor shown in the diagram?

A 1 only

B 3 only

C 1 and 2 only

D 2 and 3 only

[Turn over

8. An investigation was carried out to determine the effect of lead ion concentration on the activity of the enzyme amylase.

The results are shown in the table.

Lead ion concentration (mol l^{-1})	*Amylase activity* (% of control)
0·0 (control)	100
0·1	84
0·2	23
0·3	11
0·4	2
0·5	0

A conclusion that can be drawn from these results is that inhibition was

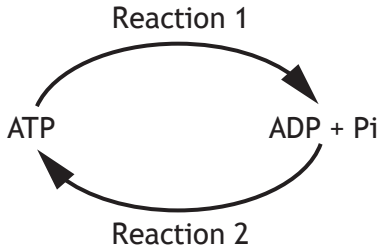
A highest at high lead ion concentrations

B highest at low lead ion concentrations

C lowest at lead ion concentration 0·5 mol l^{-1}

D highest at lead ion concentration 0·1 mol l^{-1}.

9. ATP is recycled to transfer energy within cells. The diagram shows two reactions involving ATP.

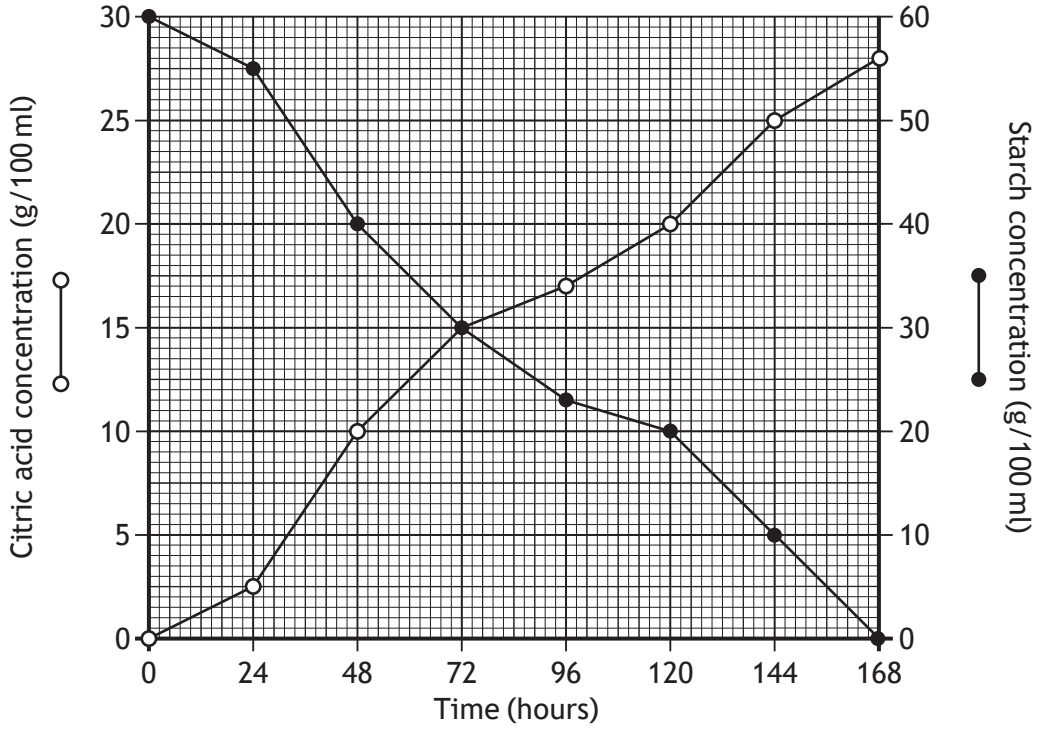


Which row in the table describes Reaction 1 and Reaction 2?

	Reaction 1	*Reaction 2*
A	catabolic and energy released	anabolic and energy required
B	anabolic and energy released	catabolic and energy required
C	catabolic and energy required	anabolic and energy released
D	anabolic and energy required	catabolic and energy released

10. The fungus *Aspergillus niger* is grown in large fermenters to produce citric acid using starch as a substrate.

The graph shows the changes in the citric acid and starch concentrations in a fermenter over 168 hours.



The citric acid concentration equals the starch concentration at

A 0 hours

B 48 hours

C 72 hours

D 120 hours.

[Turn over

11. The following list describes changes which take place during temperature regulation in mammals.

1 Vasodilation

2 Vasoconstriction

3 Contraction of hair erector muscles

4 Relaxation of hair erector muscles

Which of these changes takes place in response to a decrease in body temperature?

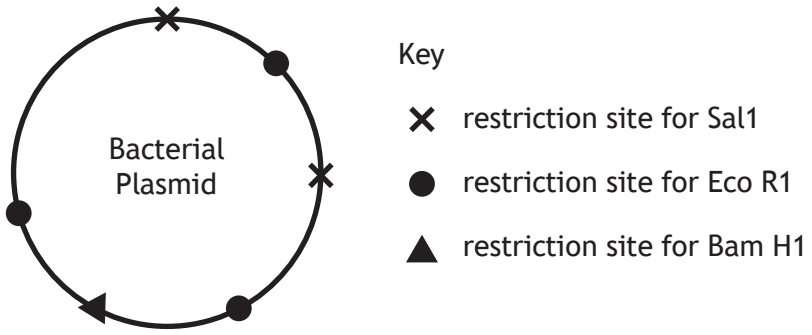
A 1 and 3 only

B 1 and 4 only

C 2 and 3 only

D 2 and 4 only

12. The diagram shows a bacterial plasmid with restriction sites for three different restriction endonucleases, Sal1, Eco R1 and Bam H1.



Which row in the table identifies the number of fragments produced if the plasmid was cut with the combinations of restriction endonucleases shown?

	Combination	
	Sal1 and Bam H1	*Sal1 and Eco R1*
A	3	4
B	3	5
C	4	4
D	4	5

13. Inbreeding depression is a result of

A an increase in heterozygotes
B a genetically variable population
C crossbreeding for improved characteristics
D an accumulation of recessive deleterious alleles.

14. Livestock production generates less food per unit area of land than crop production because

A energy is gained between trophic levels of the food chain
B livestock production degrades natural resources
C energy is lost between trophic levels of the food chain
D it is easier to grow crops than raise livestock in difficult habitats.

15. The table shows optimum, maximum and minimum temperatures for the growth of some crop plants.

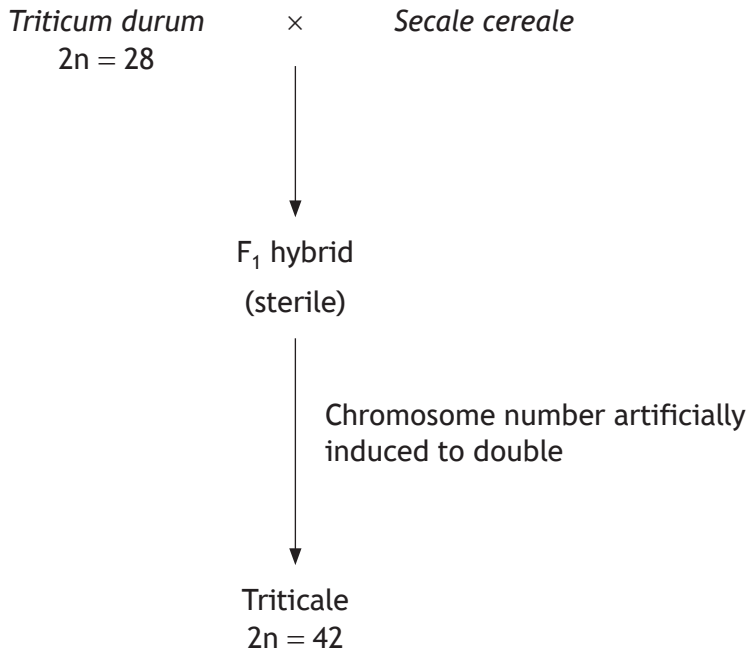
	Temperature (°C)		
Crop	*Optimum*	*Maximum*	*Minimum*
Maize	22–26	32–34	20–22
Wheat	20–25	36–38	5–7
Rice	30–33	37–40	18–22
Potato	15–20	28–34	12–14
Soyabean	25–28	37–40	10–14

Which of the following predictions is supported by the evidence in the table?

A Maize will grow at lower temperatures than soyabean.
B Rice will grow at higher temperatures than soyabean.
C Rice will grow in a narrower range of temperatures than maize.
D Wheat will grow in a wider range of temperatures than potato.

[Turn over

16. Triticale is a hybrid cereal species which was produced by crossing *Triticum durum* (a species of wheat) with *Secale cereale* (a species of rye) as shown in the diagram.



What was the diploid (2n) number of chromosomes in *Secale cereale*?

A 7

B 14

C 21

D 28

17. The following statements describe symbiotic relationships between organisms.

1 Mistletoe plants absorb nutrients from apple trees on which they grow.

2 Egyptian Plover birds clean the teeth of Nile crocodiles and feed on the debris they remove.

3 Tapeworms live in the small intestine of pigs and absorb some of their nutrients.

Which of these relationships can be described as parasitic?

A 2 only

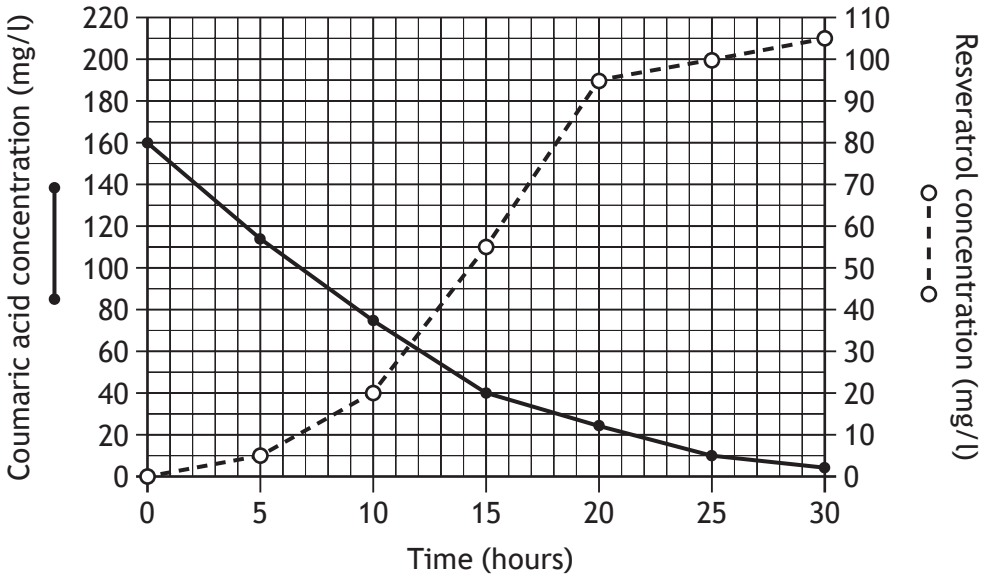
B 3 only

C 1 and 2 only

D 1 and 3 only

18. Resveratrol is a substance which may reduce the risk of heart disease. Using recombinant DNA technology, *E. coli* bacteria have been modified so that they now produce resveratrol when grown in a medium containing coumaric acid.

The graph shows concentrations of resveratrol and coumaric acid in the medium over a 30 hour period.



The simplest whole number ratio of the concentration of resveratrol to coumaric acid after 25 hours is

A 1 : 2

B 1 : 40

C 10 : 1

D 20 : 1.

19. Which row in the table identifies how the bottleneck effect and habitat corridors may change genetic diversity of a population?

	Change in genetic diversity	
	Bottleneck effect	*Habitat corridors*
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

[Turn over

20. Some species of social insect are of economic importance to humans by providing ecosystem services.

Which of the following are examples of ecosystem services?

1 Braconid wasps parasitising hornworms which are a pest of tomatoes.

2 Bumblebees pollinating an orchard of apple trees.

3 Worker termites caring for the queen and her offspring.

A 1 and 2 only

B 1 and 3 only

C 2 and 3 only

D 1, 2 and 3

[END OF SECTION 1. NOW ATTEMPT THE QUESTIONS IN SECTION 2 OF YOUR QUESTION AND ANSWER BOOKLET.]

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National Qualifications 2017

Mark

X707/76/01

Biology
Section 1 — Answer Grid and Section 2

TUESDAY, 23 MAY
9:00 AM – 11:30 AM

X7077601

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Number of seat

Date of birth

Day	Month	Year

Scottish candidate number

Total marks — 100

SECTION 1 — 20 marks

Attempt ALL questions.

Instructions for the completion of Section 1 are given on *Page 02*.

SECTION 2 — 80 marks

Attempt ALL questions.

Questions 10 and 15 contain a choice.

Write your answers clearly in the spaces provided in this booklet. Additional space for answers and rough work is provided at the end of this booklet. If you use this space you must clearly identify the question number you are attempting. Any rough work must be written in this booklet. You should score through your rough work when you have written your final copy.

Use **blue** or **black** ink.

Before leaving the examination room you must give this booklet to the Invigilator; if you do not, you may lose all the marks for this paper.

SQA ©

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SECTION 1 — 20 marks

The questions for Section 1 are contained in the question paper X707/76/02.

Read these and record your answers on the answer grid on *Page 03* opposite.

Use **blue** or **black** ink. Do NOT use gel pens or pencil.

1. The answer to each question is **either** A, B, C or D. Decide what your answer is, then fill in the appropriate bubble (see sample question below).

2. There is **only one correct** answer to each question.

3. Any rough working should be done on the additional space for answers and rough work at the end of this booklet.

Sample Question

The thigh bone is called the

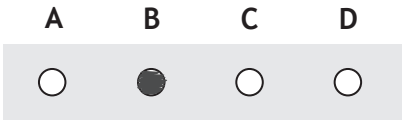
A humerus

B femur

C tibia

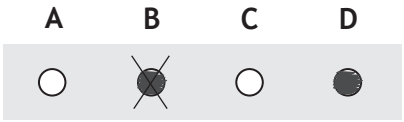
D fibula.

The correct answer is **B** — femur. The answer **B** bubble has been clearly filled in (see below).

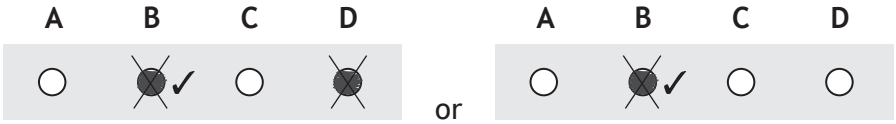


Changing an answer

If you decide to change your answer, cancel your first answer by putting a cross through it (see below) and fill in the answer you want. The answer below has been changed to **D**.



If you then decide to change back to an answer you have already scored out, put a tick (✓) to the **right** of the answer you want, as shown below:



SECTION 1 — Answer Grid

OBJ20AD1

	A	B	C	D
1	○	○	○	○
2	○	○	○	○
3	○	○	○	○
4	○	○	○	○
5	○	○	○	○
6	○	○	○	○
7	○	○	○	○
8	○	○	○	○
9	○	○	○	○
10	○	○	○	○
11	○	○	○	○
12	○	○	○	○
13	○	○	○	○
14	○	○	○	○
15	○	○	○	○
16	○	○	○	○
17	○	○	○	○
18	○	○	○	○
19	○	○	○	○
20	○	○	○	○

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[Turn over for next question

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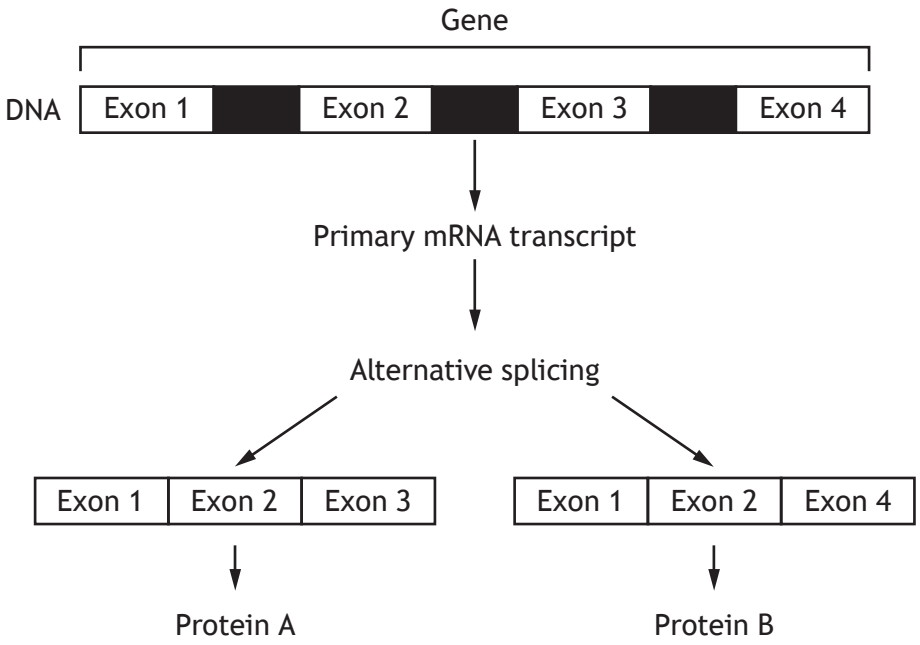
SECTION 2 — 80 marks

Attempt ALL questions

Note that Questions 10 and 15 contain a choice

1. The diagram illustrates steps in the transcription and translation of a gene.



(a) Name the regions always removed from a primary mRNA transcript. **1**

_____

(b) Insert numbers in the boxes below to show the three exons in the gene shown above which could be translated to produce a protein which is different from proteins A and B. **1**

Exon _____	Exon _____	Exon _____

1. (continued)

(c) Single gene mutations can occur which may affect the structure of the proteins produced.

(i) Describe the effect of a nonsense mutation on Protein A and give a reason for your answer. **2**

Description _____

_____

Reason _____

_____

(ii) A deletion mutation occurred in Exon 2.

Explain why this would have a major effect on the structure of proteins A and B. **1**

_____

_____

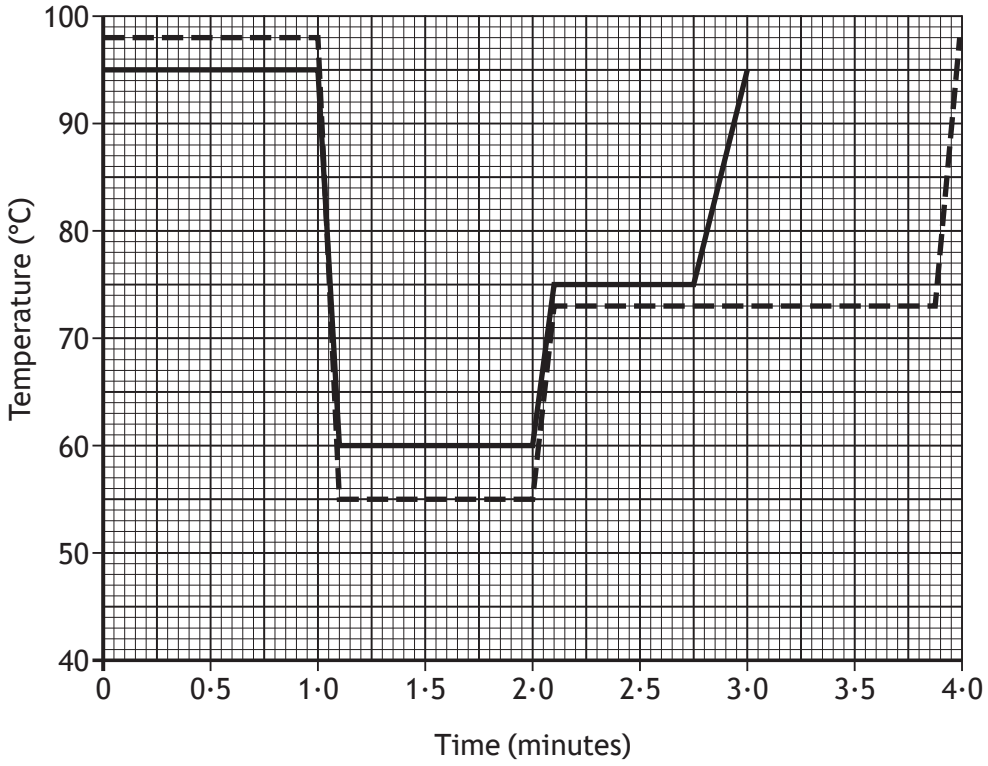
_____

[Turn over

2. Two heat-tolerant DNA polymerases used in polymerase chain reactions (PCR) are *Taq* and *Pfu*.

Pfu has "proof reading" activity. It checks that the correct nucleotides are inserted during replication of a target sequence and then corrects any errors.

The graph shows the temperatures during a single PCR cycle required to amplify a target sequence using *Taq* and *Pfu*.



(a) (i) Calculate the time taken for 16 copies of the target sequence to be made from one DNA fragment using *Taq* polymerase. **1**

Space for calculation

_____ minutes

2. (a) (continued)

(ii) Identify the time period during which primers bind to the original DNA fragment. **1**

from _____ to _____ minutes.

(b) A scientist was planning to amplify DNA using PCR.

State which DNA polymerase should be used and describe the advantage of using this polymerase. **1**

DNA polymerase _____

Advantage _____

_____

(c) Explain the importance of using heat-tolerant DNA polymerases in PCR. **1**

_____

_____

[Turn over

MARKS DO NOT WRITE IN THIS MARGIN

3. The herbicide glyphosate is used to control the annual weed charlock (*Sinapis arvensis*) in cereal fields.

An investigation was carried out into the effect of glyphosate on the development of glyphosate resistance in charlock plants in a cereal plot.

The charlock plants were treated with glyphosate from 2009 to 2016 and the percentage of glyphosate resistant plants in the plot was recorded every year.

The results are shown in the table.

Year	*Charlock plants resistant to glyphosate* (%)
2009	10
2010	18
2011	32
2012	42
2013	53
2014	58
2015	66
2016	66

(a) Using values from the table describe the change in glyphosate resistance over the time of investigation. **2**

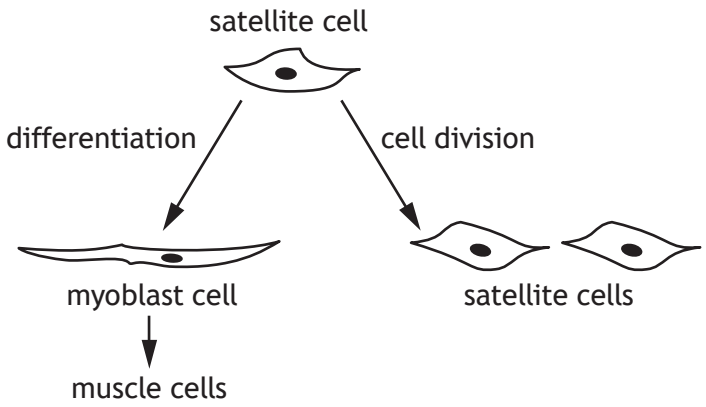
(b) Explain how natural selection resulted in the change in glyphosate resistance. **2**

(c) Another investigation was carried out into the development of antibiotic resistance in bacteria. It was observed to be more rapid than the development of glyphosate resistance in charlock.

Explain this observation in terms of gene transfer. **1**

4. (a) Human muscles contain satellite cells within the muscle tissue.

The diagram illustrates the division and differentiation of satellite cells.



(i) Using information from the diagram explain why satellite cells are an example of tissue (adult) and not embryonic stem cells. **1**

(ii) State **one** benefit to the human body of satellite cells differentiating into myoblast cells. **1**

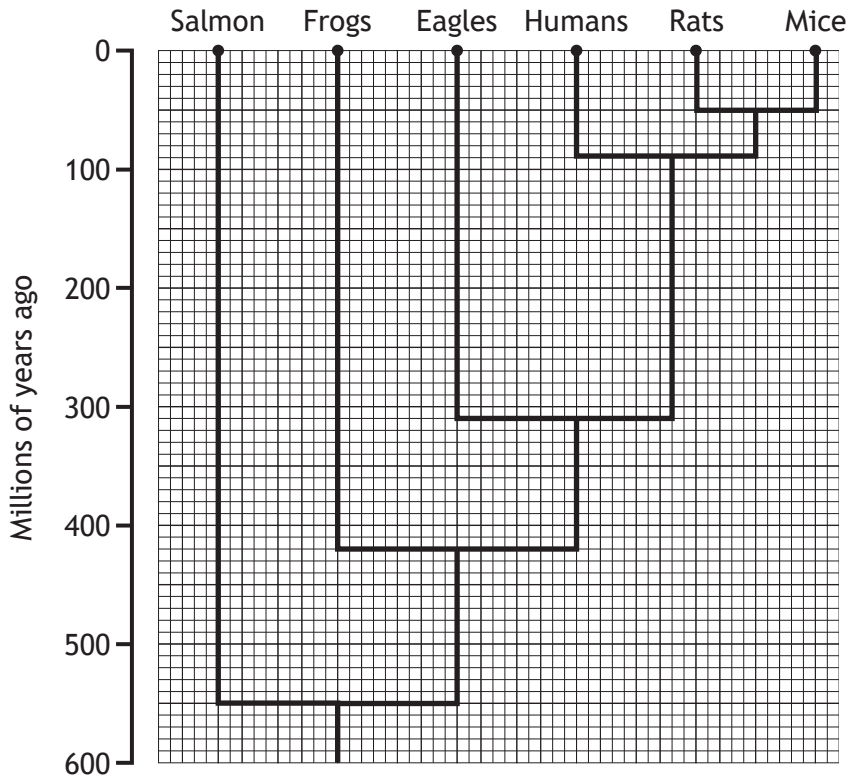
(iii) Satellite cells could be used to treat muscle diseases.

Give **one** ethical reason for using satellite cells instead of embryonic stem cells in order to treat such diseases. **1**

(b) Give **one** example of how stem cells are used as model cells in medical research. **1**

[Turn over

5. (a) The phylogenetic tree illustrates the evolutionary relatedness of six groups of animals.



(i) Using information from the phylogenetic tree state when the last common ancestor of salmon and frogs lived. **1**

_____ million years ago

(ii) Calculate how many million years separate the divergence of eagles and humans from the divergence of rats and mice. **1**

Space for calculation

_____ million years

(iii) Rats are more closely related to humans than they are to frogs.

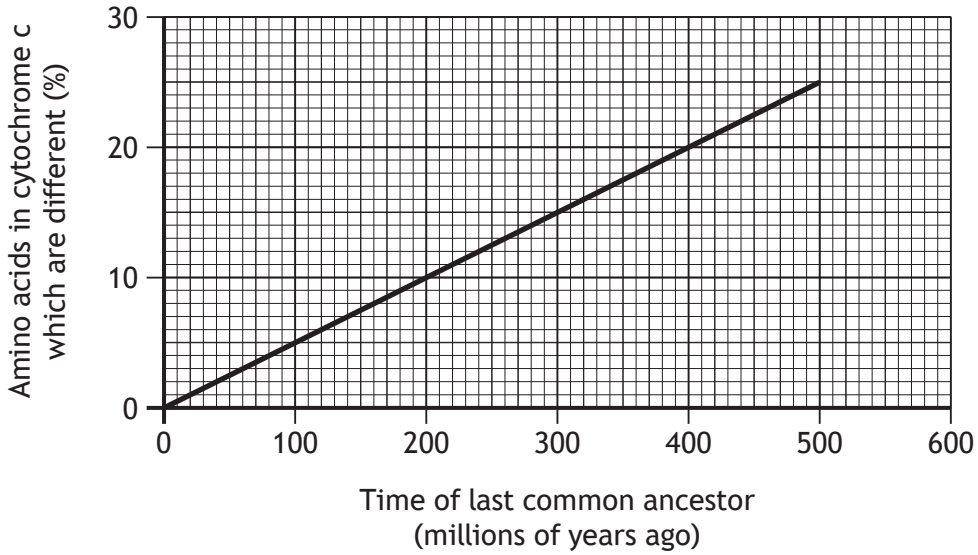
Use evidence from the phylogenetic tree to justify this statement. **1**

_____

_____

5. (continued)

(b) The graph shows a molecular clock which compares the amino acid sequence of the protein cytochrome c between a range of species.



(i) Cytochrome c is a protein containing 112 amino acids.

Calculate the number of amino acids in cytochrome c that are different between two species whose last common ancestor lived 500 million years ago. **1**

Space for calculation

_____

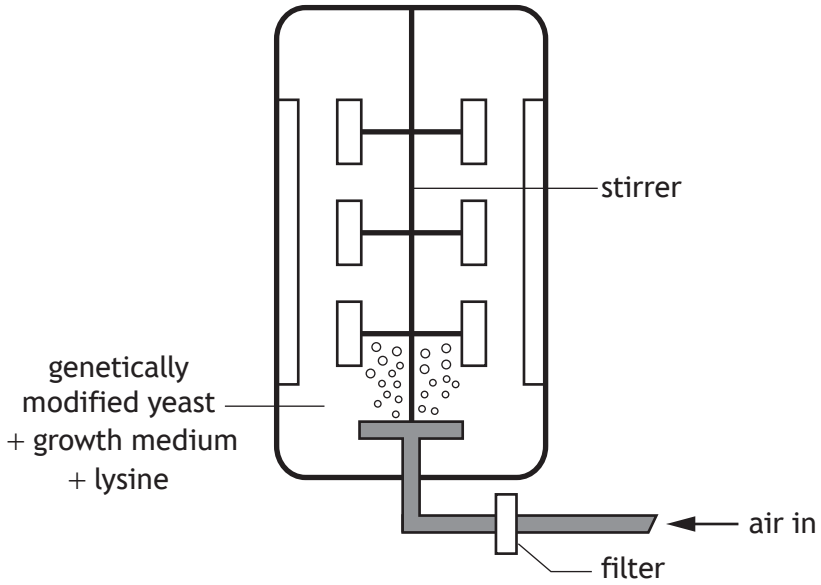
(ii) Predict the percentage of amino acids in cytochrome c which would be different between two species who shared a common ancestor 550 million years ago. **1**

_____%

(c) Using information from the **phylogenetic tree and the graph**, state the percentage of amino acids in cytochrome c that are different between rats and frogs. **1**

_____%

6. The diagram shows genetically modified yeast growing in a fermenter in a medium to which the amino acid lysine has been added.



(a) (i) Name the process for which the yeast cells need the amino acid lysine. **1**

_____

(ii) The fermenter contains 5·5 litres of growth medium.

Calculate the mass of lysine which should be added to the medium to give a concentration of 300 mg/l. **1**

Space for calculation

_____ mg

(iii) The air entering the fermenter passes through a filter to prevent contamination.

Explain why it is necessary to prevent contamination of the culture. **1**

_____

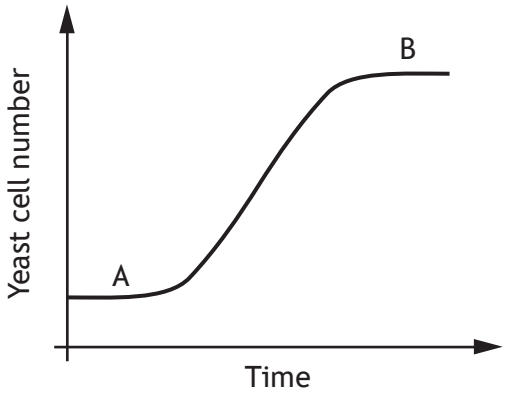
_____

6. (a) (continued)

(iv) The optimum pH for yeast growth is 4·5.

Suggest how this pH could be maintained in the fermenter. **1**

(b) Some phases of a growth curve of yeast culture are shown.



Complete the table by selecting growth phase A **or** B. Name the chosen phase and describe an event which occurs during that phase of growth. **2**

Letter	*Phase of growth*	*Description*

(c) Describe a safety mechanism used to prevent the survival of genetically modified microorganisms in the external environment. **1**

[Turn over

7. Sea bass are saltwater fish that can regulate their internal salt concentration. They have specialised cells in their gills with protein pumps in the membrane. These pumps actively transport excess salt from their bodies.

(a) The specialised cells have many mitochondria.

Explain why this is necessary. **2**

(b) Many animal species regulate their body temperature.

Explain the importance of regulating body temperature. **1**

(c) Compare regulators and conformers in terms of their ecological niches. **1**

[Turn over for next question

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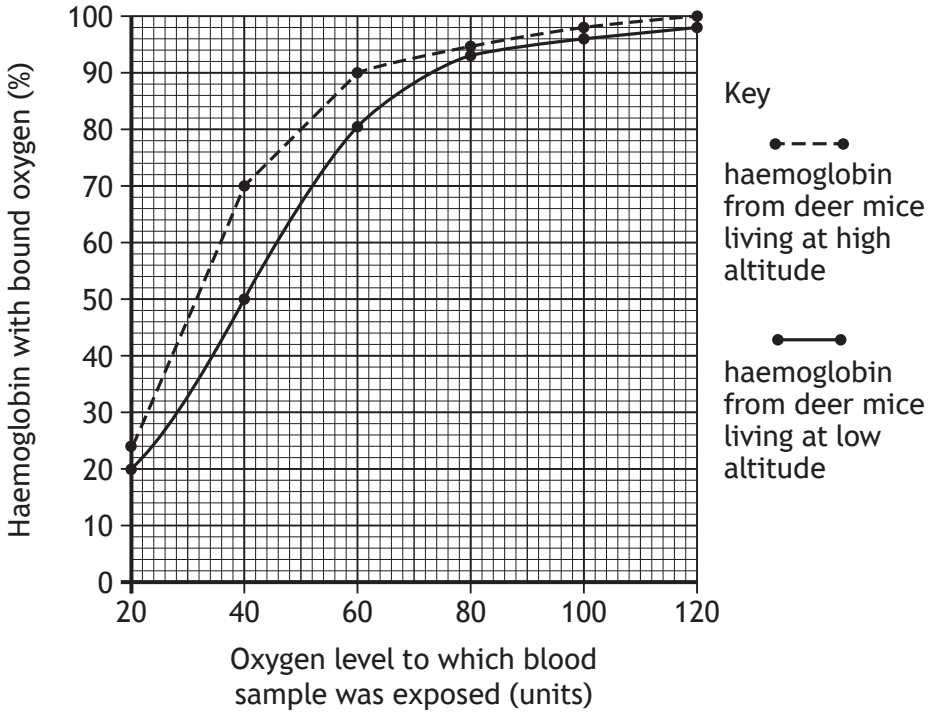
8. Deer mice (*Peromyscus maniculatus*) are small mammals living in a variety of habitats ranging from low to high altitude.

An investigation was carried out to compare the haemoglobin from two populations of deer mice living at low and high altitudes.

Blood samples were taken from both populations and exposed to different levels of oxygen. The percentage of haemoglobin in the blood samples which had oxygen bound to it was measured.

The results are shown in the graph.



(a) (i) State **one** variable that should be controlled when exposing the blood samples to oxygen in order for a valid conclusion to be drawn. **1**

_____

8. (a) (continued)

(ii) State the oxygen level at which there is the greatest difference in the percentage of haemoglobin bound to oxygen between the two groups. **1**

_____ units

(iii) Use information from the graph to explain how the deer mice from the population living at high altitude are adapted to a low oxygen niche. **1**

_____

_____

(b) Suggest **one** physiological adaptation, other than differences in haemoglobin, that deer mice from high altitudes could have to increase the efficiency of oxygen delivery to cells. **1**

_____

_____

(c) Describe the structure of a deer mouse heart and explain how this allows efficient delivery of oxygen to cells. **2**

Description _____

_____

Explanation _____

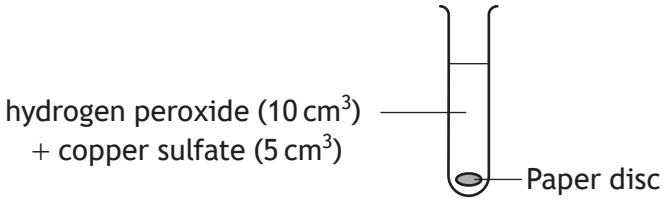
_____

[Turn over

9. Catalase is an enzyme which breaks down hydrogen peroxide into oxygen and water. Paper discs soaked in catalase sink when placed into hydrogen peroxide solution. The discs rise to the surface when oxygen is produced. The time taken for the discs to rise can be used to measure catalase activity.

An experiment was set up to investigate the effect of copper sulfate concentration on catalase activity.

Six tubes were set up, each containing 10 cm^3 of hydrogen peroxide and 5 cm^3 of a different concentration of copper sulfate. One paper disc was then placed into each test tube as shown in the diagram. The time taken for each paper disc to rise to the surface was recorded.



The results are shown in the table.

Concentration of copper sulfate solution (mol l^{-1})	*Time taken for paper disc to rise* (seconds)
0·2	8
0·3	12
0·4	15
0·6	18
0·8	19
1·0	20

(a) (i) Name the independent variable in this experiment. **1**

(ii) Describe a suitable control for this experiment. **1**

(iii) Suggest how the temperature of the tubes could be kept constant. **1**

9. (a) (continued)

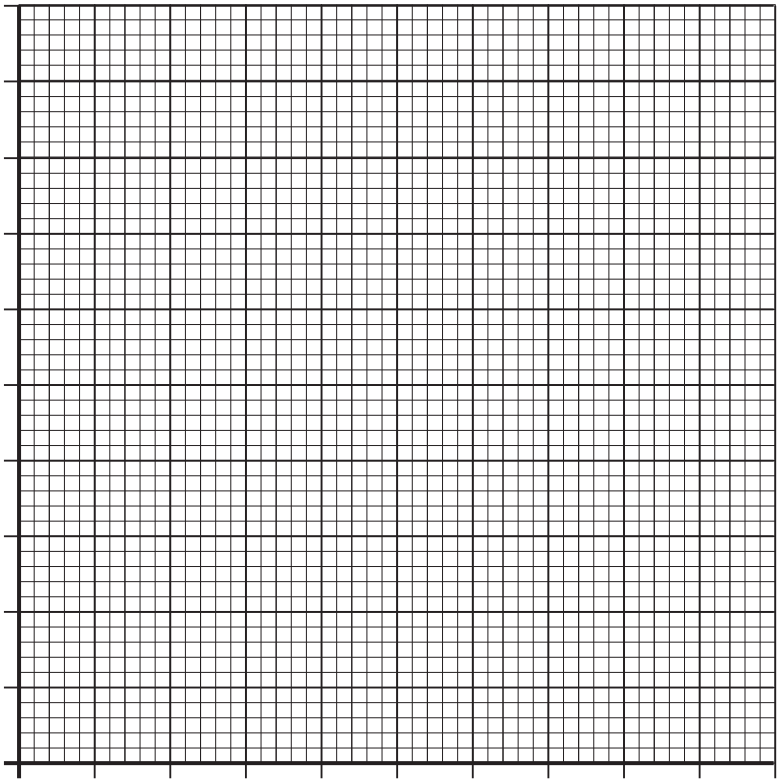
(iv) Give a feature of the experiment which may make the results unreliable. **1**

_____

_____

(b) (i) Draw a line graph using the results in the table.

(Additional graph paper, if required, will be found on *Page 32*.) **2**



(ii) Calculate the percentage increase in the time taken for the paper disc to rise when the copper sulfate concentration increased from $0{\cdot}2\,mol\,l^{-1}$ to $1{\cdot}0\,mol\,l^{-1}$. **1**

Space for calculation

_____%

(c) Draw a conclusion from the results of this experiment. **1**

_____

_____

MARKS | DO NOT WRITE IN THIS MARGIN

10. Answer **either A or B** in the space below.

A Write notes on primate behaviour. **4**

OR

B Write notes on invasive species. **4**

11. During photosynthesis light energy is absorbed by photosynthetic pigments in the chloroplasts.

(a) (i) State one fate of the light which is **not** absorbed by the photosynthetic pigments. **1**

_____

(ii) Describe the effect of absorbed light energy on the pigment molecules. **1**

_____

_____

(iii) Plants contain several pigments including chlorophyll a, chlorophyll b and carotenoids. Explain the advantage to a plant of having more than one type of photosynthetic pigment. **1**

_____

_____

(b) Following photolysis, hydrogen is transferred to the coenzyme NADP.

State the source of this hydrogen. **1**

_____

(c) Describe the role of the NADPH in the Calvin cycle (carbon fixation). **1**

_____

_____

[Turn over

12. Potato plants are attacked by leaf eating caterpillars. *Bacillus thuringiensis* is a bacterium which can be used to control these pests. The bacteria produce a protein (Bt toxin) which kills these caterpillars.

(a) (i) Explain how an attack by leaf eating caterpillars causes a reduction in crop yield. **2**

(ii) State an advantage of using this type of biological control rather than using chemicals. **1**

(b) Bt toxin does not kill all caterpillars.

A study was carried out to investigate the effectiveness of the Bt toxin compared with a modified Bt toxin by exposing different groups of caterpillars to them.

The results are shown in the table.

Toxin tested	*Number of caterpillars tested*	*Number of caterpillars surviving*	*Caterpillars killed* (%)
Bt toxin alone	240	204	
Modified Bt toxin alone	300	105	65
Bt toxin and modified Bt toxin used together	210	42	80

(i) Complete the table to show the percentage of caterpillars killed by the Bt toxin alone. **1**

Space for calculation

12. (b) (continued)

(ii) The Bt toxin and modified Bt toxin work by different mechanisms. Use information from the table to justify this statement. **1**

_____

_____

_____

[Turn over

13. Gluten is a protein found in crops that can cause human health problems. Scientists are breeding barley cultivars to produce ultra low gluten levels.

A commercially produced barley (Sloop) and a low gluten cultivar (LG) were crossed to produce two different cultivars with ultra low gluten levels (ULG 1 and ULG 2).

The gluten content of each cultivar is shown in the table.

Barley cultivar	*Gluten content* (mg/g)
Sloop	57·0
LG	5·1
ULG 1	1·7
ULG 2	0·004

(a) Calculate how many times greater the gluten content of Sloop is compared to that of ULG 2. **1**

Space for calculation

_____ times greater

(b) The allele for ultra low gluten is recessive. To investigate if the cultivar LG was heterozygous for gluten, it was crossed with the cultivar ULG1 which was homozygous for this recessive allele.

low gluten cultivar × ULG1

↓

offspring

(i) Name this type of cross. **1**

_____

(ii) Describe the expected phenotypes of the offspring if LG was heterozygous. **1**

_____

_____

13. (continued)

(c) Barley is a naturally inbreeding plant.

Explain why inbreeding depression would be unlikely to be a problem when a barley cultivar self-pollinates for many generations. **1**

(d) Barley grains contain the enzyme amylase which breaks down starch in the grain to sugar used in brewing beer.

Average grain mass, starch content and amylase activity for three barley cultivars are shown in the table.

Barley cultivar	*Average mass of a single grain* (mg)	*Starch content of grains* (%)	*Amylase activity* (units/mg)
Sloop	53·6	70	0·6
ULG1	33·5	65	1·0
ULG2	39·2	64	1·4

(i) As well as total mass of all the grains, state the information required in order to calculate the average mass of a single grain. **1**

(ii) Select a cultivar from the table that would be best to use in beer production and justify your selection. **1**

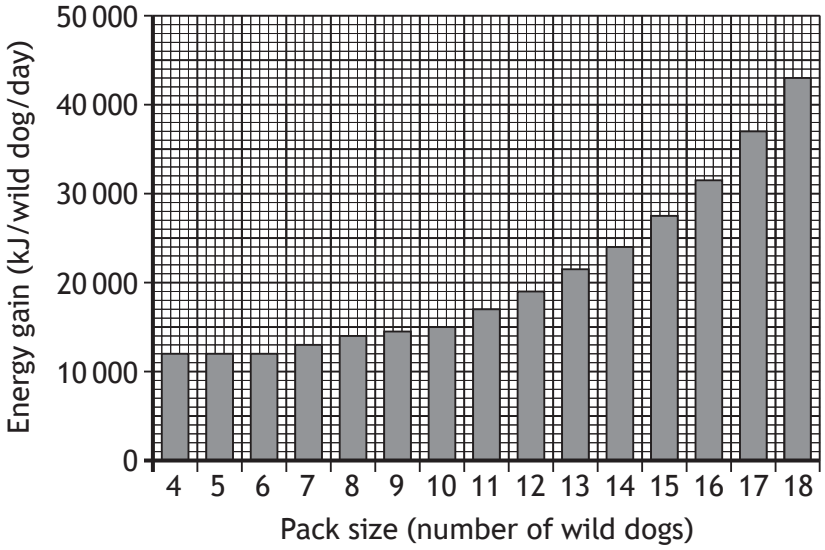
Cultivar _____

Justification _____

[Turn over

14. African wild dogs are carnivores which live in packs and use cooperative hunting. Each wild dog requires an average of 30 000 kJ of energy per day for the pack to survive.

The bar chart shows the relationship between pack size and energy gain per wild dog per day.



(a) Using information from the bar chart, state the minimum pack size

(i) at which cooperative hunting becomes an advantage; **1**

_____ wild dogs

(ii) for survival of the pack. **1**

_____ wild dogs

(b) Suggest why wild dogs in larger packs gain more energy per individual from hunting even though there are more animals to be fed. **1**

_____

_____

(c) Most of the wild dogs in a pack are related. Usually only one dominant female has offspring which other members of the pack will feed.

Explain why pack members feed offspring which are not their own. **1**

_____

_____

15. Answer **either A or B** in the space below and on *Pages 30* and *31*.

A Write notes on the citric acid cycle of cell respiration. **7**

OR

B Write notes on how animals survive and avoid adverse conditions. **7**

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SPACE FOR ANSWERS

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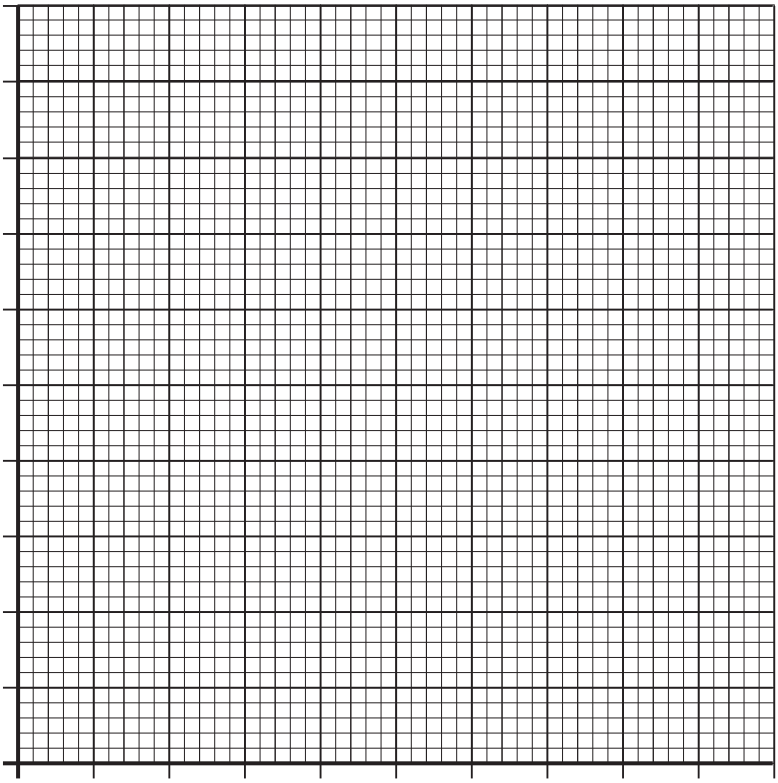
ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

ADDITIONAL GRAPH PAPER FOR QUESTION 9 (b) (i)



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