

FOR OFFICIAL USE



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National  
Qualifications  
2022

Mark

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**X807/76/01**

**Biology  
Paper 2**

THURSDAY, 19 MAY  
10:10 AM – 12:30 PM



Fill in these boxes and read what is printed below.

Full name of centre

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Town

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Forename(s)

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Surname

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Number of seat

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Date of birth

Day

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Month

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Year

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Scottish candidate number

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**Total marks — 95**

Attempt ALL questions.

**You may use a calculator.**

Questions 11 and 16 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. Score through your rough work when you have written your final copy.

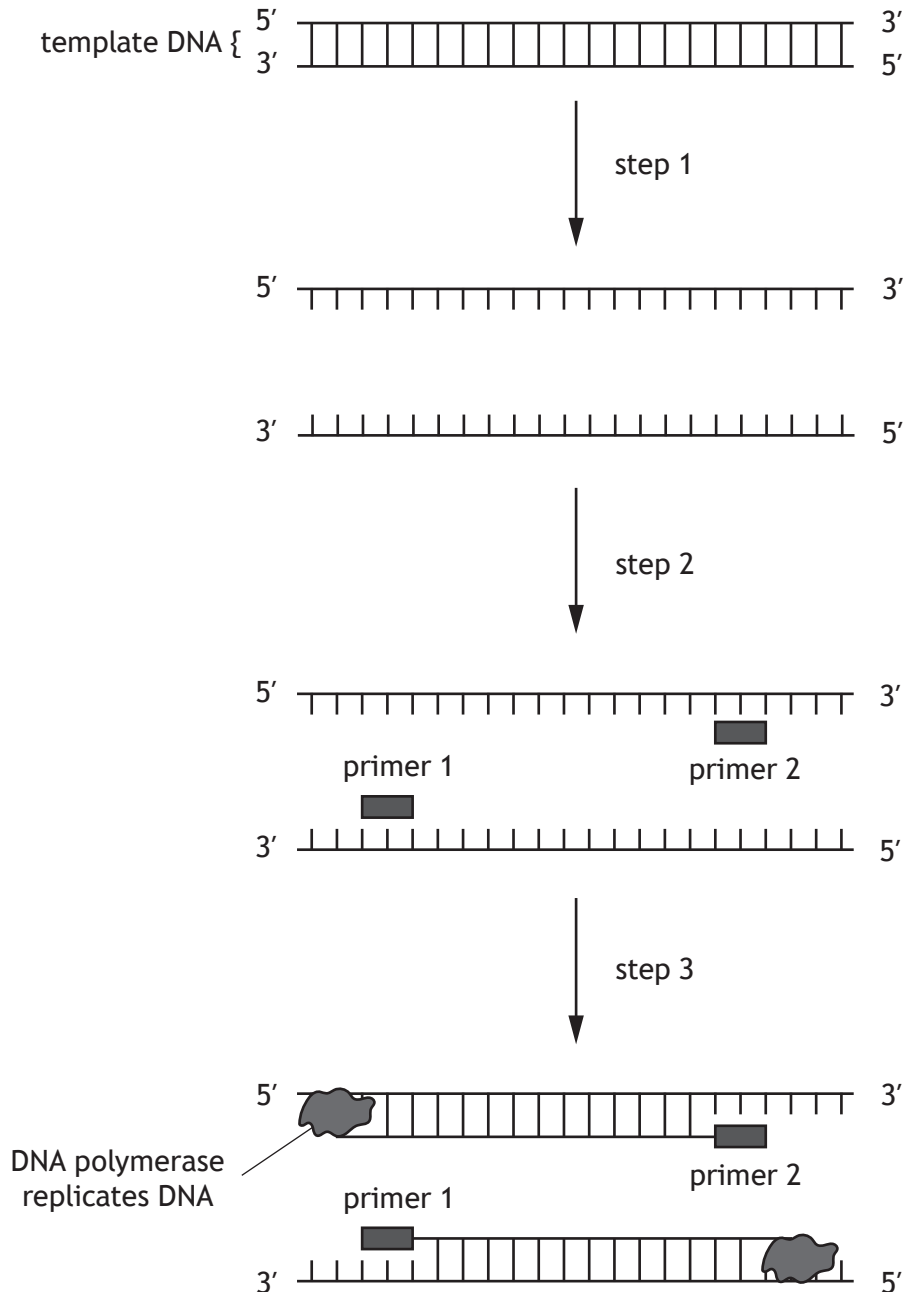
Use **blue** or **black** ink.

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.



Total marks — 95  
Attempt ALL questions  
Questions 11 and 16 contain a choice

1. Sections of DNA can be amplified using the polymerase chain reaction (PCR).  
The steps in one cycle of PCR are shown.



\* X 8 0 7 7 6 0 1 0 2 \*

1. (continued)

(a) (i) Give a temperature for step 1 to occur. 1

\_\_\_\_\_ °C

(ii) Describe one role of the primers in PCR. 1

\_\_\_\_\_  
\_\_\_\_\_

(b) (i) The diagram shows the role of DNA polymerase in PCR. 2  
Name another enzyme necessary for DNA replication in cells.  
Suggest why this enzyme is **not** required for step 3 in PCR.

Name \_\_\_\_\_

Suggestion \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

(ii) Explain why DNA polymerase extracted from human cells would not replicate DNA in PCR. 1

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\_\_\_\_\_

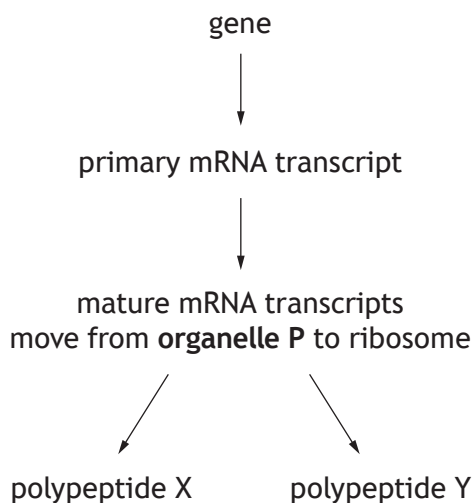
(c) State one practical application of PCR. 1

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\_\_\_\_\_

[Turn over



2. Cell growth depends on the transcription of genes and translation into protein. The processes of transcription of a gene and translation are represented in the diagram.



- (a) Name organelle P. 1

\_\_\_\_\_

- (b) Alternative splicing of the primary mRNA transcript has occurred.  
 (i) Use evidence from the diagram to support this statement. 1

\_\_\_\_\_  
 \_\_\_\_\_

- (ii) Describe the process of alternative RNA splicing. 1

\_\_\_\_\_  
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2. (continued)

- (c) An investigation was carried out into transcription and translation in human cells. The cells were cultured in a growth medium containing radioactive uracil. This allows the uracil to be detected in any molecule it is used to synthesise.

Explain why ribosomes would contain radioactive uracil.

1

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[Turn over



3. Evolution by natural selection is more rapid in prokaryotes than eukaryotes.  
*Staphylococcus aureus* is a species of bacteria that causes infections in humans. A strain of this bacteria, MRSA, has evolved to become resistant to many antibiotics.

(a) Explain why evolution by natural selection is more rapid in prokaryotes. 1

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(b) Use your knowledge of natural selection to explain how the use of antibiotics has led to the evolution of MRSA. 2

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3. (continued)

- (c) The table shows the number of hospital deaths in a region of the UK as a result of infections caused by MRSA and non-resistant *Staphylococcus aureus* from 2005 to 2016.

Year	Number of hospital deaths caused by <i>Staphylococcus aureus</i>	
	MRSA	Non-resistant <i>Staphylococcus aureus</i>
2005	258	71
2007	272	71
2010	112	72
2013	107	70
2016	93	71

- (i) Describe the overall trend in the number of deaths caused by MRSA and non-resistant *Staphylococcus aureus* infections from 2005 to 2016.

2

MRSA \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Non-resistant *Staphylococcus aureus* \_\_\_\_\_  
 \_\_\_\_\_

- (ii) Control measures were introduced in hospitals to reduce the spread of MRSA.

Using information from the table, suggest a year that these measures may have been introduced.

1

\_\_\_\_\_

- (iii) Treatment of MRSA is more successful when the individual's genomic sequence is used to select the most effective drug.

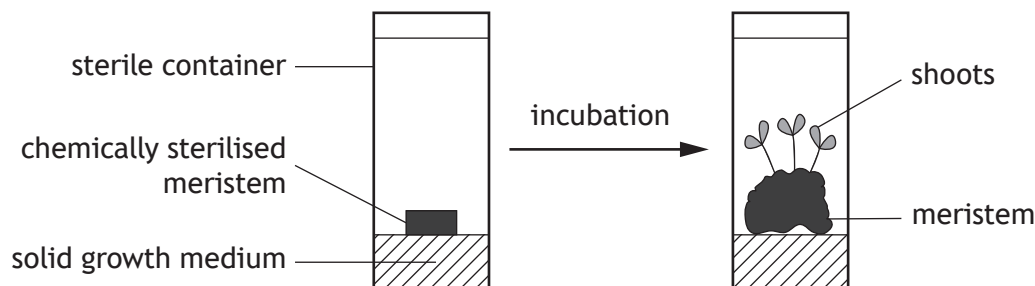
Name this approach.

1

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4. Plant tissue culture is a technique used to produce plants, which is carried out under sterile conditions to prevent growth of microorganisms.
- In an investigation to study root and shoot formation a meristem was placed on solid growth medium as shown and left to incubate.



(a) Shoots were produced as a result of cellular differentiation.

- (i) Describe how unspecialised cells in the meristem differentiate into specialised cells.

1

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- (ii) New meristem cells would form in addition to shoots.  
Name the cell process responsible for this.

1

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(b) Suggest why shoot growth would be reduced if the investigation was set up in non-sterile conditions.

2

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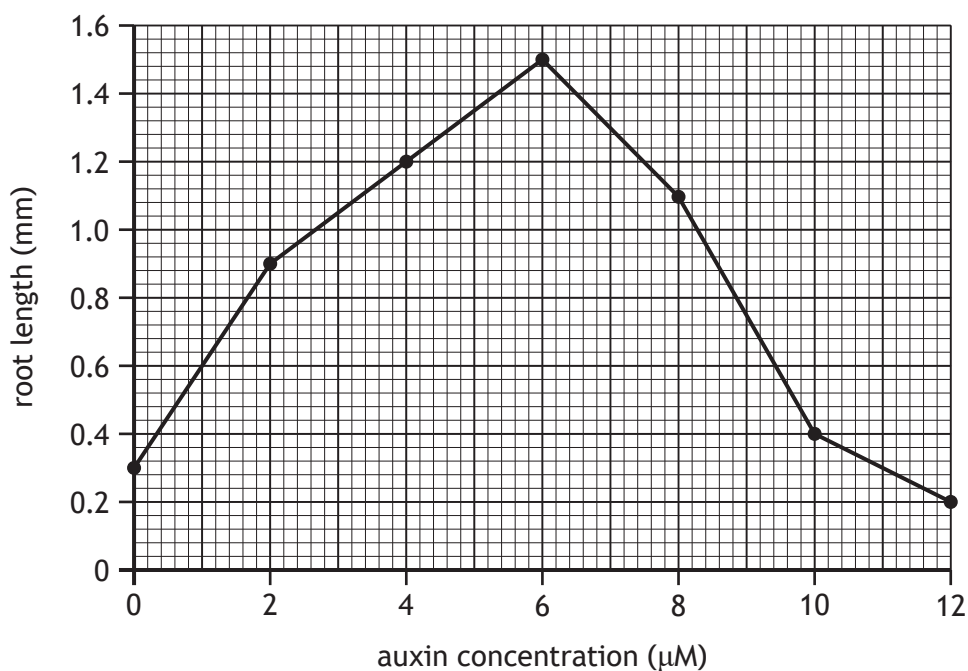


4. (continued)

- (c) A plant growth substance called auxin can be added to the growth medium to stimulate root formation by meristems.

A second investigation was carried out to determine the effect of auxin concentration on root length.

The results are shown in the graph.



- (i) Calculate the average increase in root length per  $\mu\text{M}$  of auxin between 0 and 6  $\mu\text{M}$ .

1

Space for calculation

\_\_\_\_\_ mm/ $\mu\text{M}$

- (ii) Identify an auxin concentration at which the growth of roots is inhibited.

1

\_\_\_\_\_  $\mu\text{M}$

[Turn over



\* X 8 0 7 7 6 0 1 0 9 \*

5. Two sub-populations of squirrel are descendants of an original population that was divided when the Colorado River formed the Grand Canyon.

(a) (i) Name the type of isolation barrier that divided the original squirrel population.

1

\_\_\_\_\_

(ii) Explain how the presence of the barrier could lead to the evolution of two new species of squirrel.

2

\_\_\_\_\_  
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(iii) Name the type of speciation that may occur.

1

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(b) Suggest why the formation of the Grand Canyon is more likely to lead to speciation in ground animals than birds.

1

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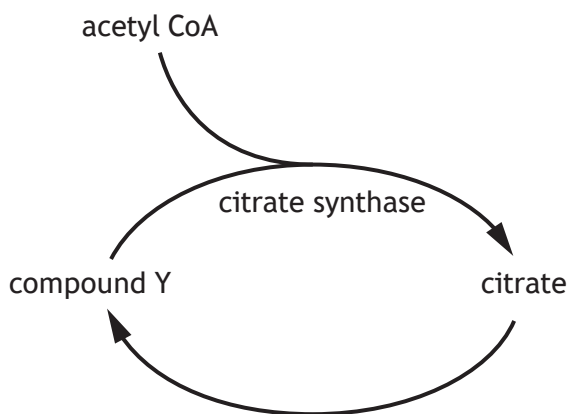
(c) Give the meaning of the term species.

1

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 \_\_\_\_\_



6. The diagram shows some steps in the citric acid cycle in human muscle cells.



(a) State the exact location of the citric acid cycle within cells.

1

\_\_\_\_\_

(b) Name compound Y.

1

\_\_\_\_\_

(c) Succinyl CoA is an intermediate in the citric acid cycle and has a similar shape to acetyl CoA.

Suggest how an increase in the concentration of succinyl CoA could decrease the activity of the enzyme citrate synthase.

1

\_\_\_\_\_  
\_\_\_\_\_

(d) During strenuous exercise oxygen concentration in muscle cells decreases and the cells carry out fermentation.

Name a product of fermentation in muscle cells.

1

\_\_\_\_\_

[Turn over



7. A study was carried out to compare the metabolic rates of different animals. The body mass and metabolic rate of each animal are shown in the table.

Animal	Body mass (kg)	Metabolic rate (kJ/kg/day)
Wood pigeon	0.3	414.0
Collared dove	0.2	447.0
Roe deer	45.0	96.0
Red deer	200.0	57.5
Herring gull	1.5	220.0

- (a) Describe the relationship between the body mass of animals and their metabolic rate.

1

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- (b) Calculate how many times greater the metabolic rate of a wood pigeon is compared to a red deer.

1

*Space for calculation*

\_\_\_\_\_ times greater

- (c) State why metabolic rate was expressed as per kg.

1

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- (d) Name a piece of equipment used in measuring metabolic rate.

1

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\* X 8 0 7 7 6 0 1 1 2 \*

7. (continued)

(e) (i) Describe the arrangement of the heart chambers in a bird.

1

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(ii) Explain how the arrangement of its heart chambers supports a bird's high metabolic rate.

2

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[Turn over



\* X 8 0 7 7 6 0 1 1 3 \*

8. Freshwater crocodiles (*Crocodylus johnsoni*) in Northern Australia aestivate for up to three months. A study was carried out to investigate aestivation in freshwater crocodiles. The body temperature, metabolic rate, and air temperature were recorded.

The results are shown in the table.

Month	Average body temperature (°C)	Average metabolic rate (kJ/kg/day)	Average air temperature (°C)
August	25.9	36.0	26.2
September	27.9	26.1	28.0
October	27.8	26.5	27.5
November	28.9	25.7	29.5
December	28.7	36.7	28.9

(a) (i) Using information from the table, identify the three-month period when the crocodiles were aestivating.

1

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(ii) Crocodiles are conformers.

Use information from the table to support this statement.

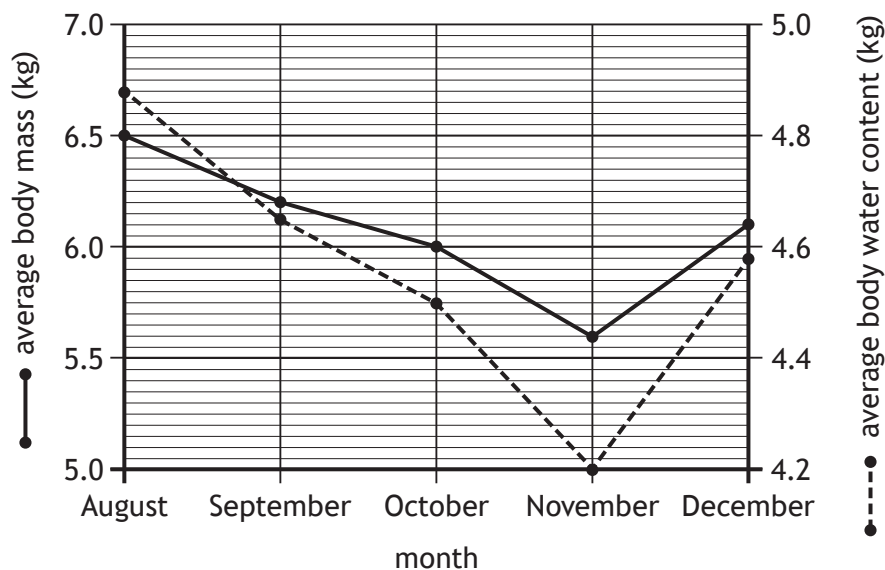
1

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(b) The graph shows the average body mass and the average body water content of the crocodiles between August and December.



\* X 8 0 7 7 6 0 1 1 4 \*

8. (b) (continued)

- (i) Using values from the graph, describe the changes in the average body mass of the crocodiles between August and December.

2

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- (ii) Calculate the average body water content of the crocodiles in November as a percentage of their average body mass.

1

*Space for calculation*

\_\_\_\_\_ %

(c) Using information from the table and the graph:

- (i) calculate the average energy consumption per day of a crocodile in October.

1

*Space for calculation*

\_\_\_\_\_ kJ/day

- (ii) state the average metabolic rate when the average body mass was 5.6 kg.

1

\_\_\_\_\_ kJ/kg/day

[Turn over



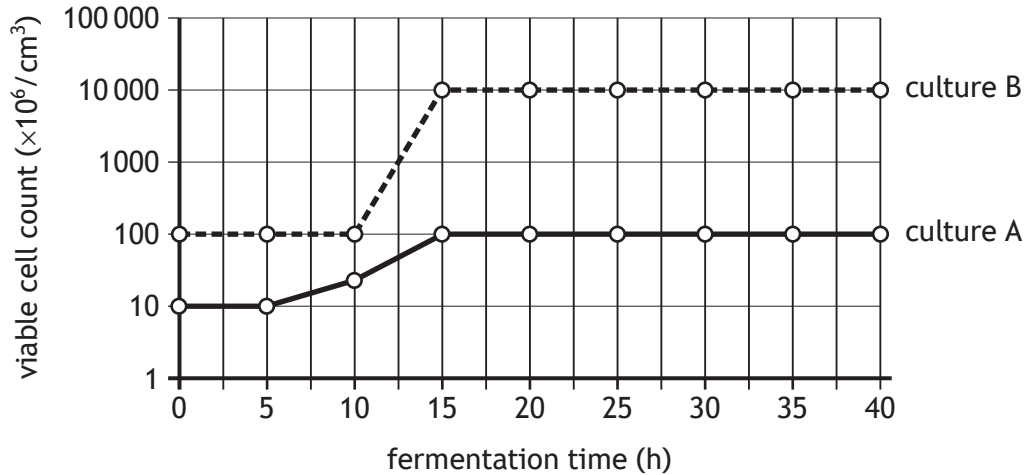
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9. The bacterium *Bacillus subtilis* (*B. subtilis*) produces antibiotics.

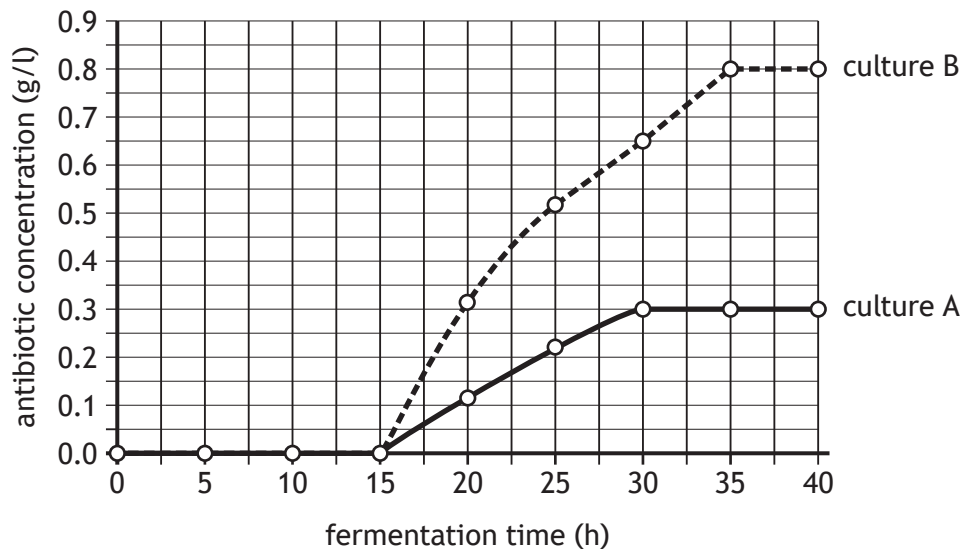
A study was carried out to compare the viable cell count and antibiotic concentration of two cultures of *B. subtilis* (A and B) grown under different conditions.

The results are shown in the graphs.

Graph 1



Graph 2



- (a) Using information in Graph 1 state the duration of the lag phase in culture A. 1

\_\_\_\_\_ hours



\* X 8 0 7 7 6 0 1 1 6 \*

9. (continued)

- (b) Using information in Graph 2 calculate the simplest whole number ratio of the antibiotic concentration in culture A to culture B at 30 hours.

1

Space for calculation

\_\_\_\_\_ : \_\_\_\_\_  
culture A      culture B

- (c) Using information in both graphs state the total viable cell count in culture A when its antibiotic concentration first reached 0.3 g/l.

1

\_\_\_\_\_ cells × 10<sup>6</sup> per cm<sup>3</sup>

- (d) Antibiotics are secondary metabolites.

- (i) Use evidence from both graphs to support this statement.

1

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

- (ii) Describe an ecological advantage to *B. subtilis* of producing antibiotics in its natural environment.

1

\_\_\_\_\_

\_\_\_\_\_

- (e) Name a culture condition that would be controlled when producing antibiotics in a fermenter.

1

\_\_\_\_\_

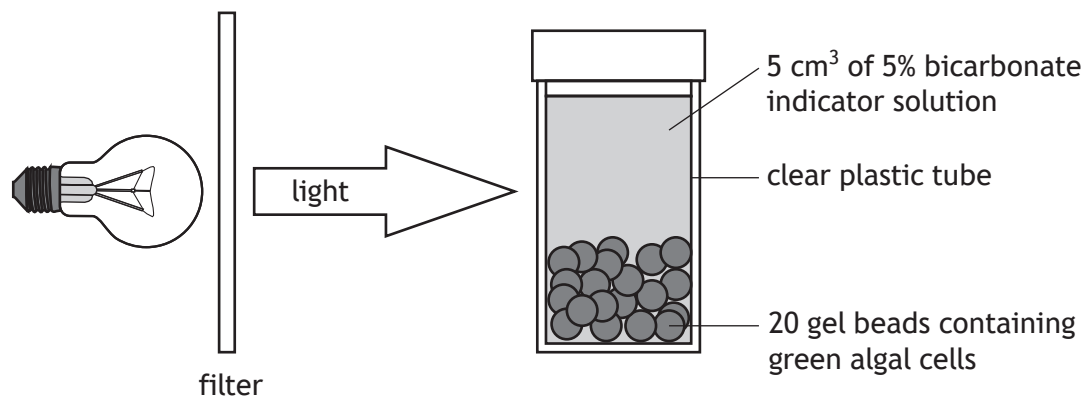
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10. An investigation was carried out to determine the wavelength of light at which the rate of photosynthesis in algal cells was greatest.

Algal cells were immobilised in gel beads and immersed in bicarbonate indicator solution. As the cells carry out photosynthesis, the colour of the indicator changes. This colour change can be measured using a colorimeter. The higher the colorimeter reading, the higher the rate of photosynthesis.

Tubes were set up as shown, each with a different filter that allowed a different wavelength of light through.



After 60 minutes, the gel beads were removed from the tubes and colorimeter readings taken.

The results are shown in the table.

Wavelength of light (nm)	Colorimeter reading (units)
400	0.40
450	0.82
500	0.24
550	0.20
600	0.34
650	0.96
700	0.22

(a) (i) Identify one variable, not already mentioned, which would have to be controlled so that a valid conclusion could be drawn.

1

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(ii) Suggest how the investigation could be improved to ensure that the algal cells are only exposed to light from the lamp.

1

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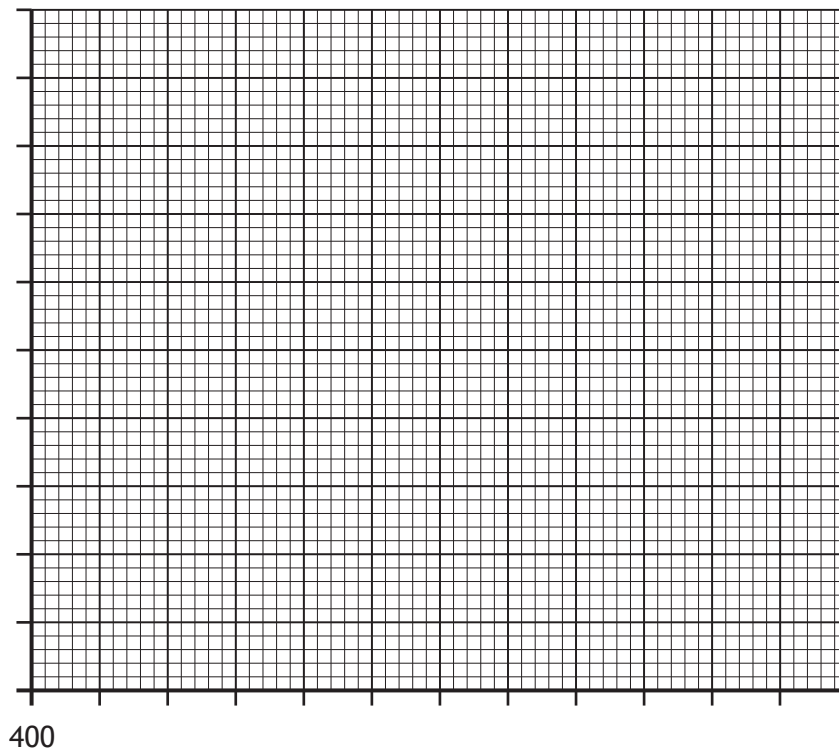
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10. (continued)

- (b) On the grid, complete the line graph using the results from the table.  
 (Additional graph paper, if required, can be found on *page 32.*)

2



- (c) (i) State the conclusion from the results of this investigation.

1

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- (ii) Describe how the experimental procedure could be improved to increase the reliability of the results.

1

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[Turn over



10. (continued)

(d) Some species of algae live under floating surface plants. These surface plants have high levels of chlorophyll, which absorb mostly red and blue light.

Suggest how the species of algae living under floating surface plants are still able to photosynthesise.

2

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11. Attempt either A or B. Write your answer in the space below.

A Write notes on problems with the use of chemicals to control pests and biological control methods to overcome these problems.

4

OR

B Write notes on behavioural indicators of poor animal welfare.

4

You may use labelled diagrams where appropriate.

[Turn over



\* X 8 0 7 7 6 0 1 2 1 \*

12. Crops such as buckwheat (*Fagopyrum esculentum*) grown in exposed regions can be damaged by the wind. Long roots help anchor crop plants in the soil, minimising damage in windy conditions.

A field trial was carried out to compare the mass of grain produced and root length of four cultivars of buckwheat, Q, R, S and T.

The plots in the trial were set up as shown in the diagram.

Q	R	S	T
S	T	Q	R
R	Q	S	T
T	S	R	Q

Each plot had the same area and contained 500 buckwheat plants.

After 12 weeks the mass of grain and the root lengths were measured.

The results are shown in the table.

Cultivar	Average mass of grain produced per plot (kg)	Average length of roots (cm)
Q	1.24	38.2
R	3.77	32.6
S	3.85	31.3
T	4.24	11.8



\* X 8 0 7 7 6 0 1 2 2 \*

12. (continued)

(a) During the field trial one side of the field was more exposed to wind than the other side.

(i) Identify a design feature of the trial that eliminated this bias.

1

\_\_\_\_\_

(ii) Describe how the investigation took into account any variability in the mass of grain and root length within plants of the same cultivar.

1

\_\_\_\_\_

\_\_\_\_\_

(b) Cultivars Q and T were crossed to produce F<sub>1</sub> hybrids, which may be successfully grown in windy conditions.

Use information from the table to explain why these cultivars were selected.

2

Cultivar Q \_\_\_\_\_

\_\_\_\_\_

Cultivar T \_\_\_\_\_

\_\_\_\_\_

(c) Explain why F<sub>1</sub> hybrids are not usually bred together in plant breeding programmes.

1

\_\_\_\_\_

\_\_\_\_\_

[Turn over



\* X 8 0 7 7 6 0 1 2 3 \*

13. Corals are marine animals that have a symbiotic relationship with microscopic photosynthetic algae called zooxanthellae. They both benefit from this relationship.

The zooxanthellae live inside the coral cells and receive the light reflected from the coral.

(a) (i) Name this type of symbiotic relationship.

1

\_\_\_\_\_

(ii) Suggest the benefit that each organism gains from the relationship.

2

Coral \_\_\_\_\_

\_\_\_\_\_

Zooxanthellae \_\_\_\_\_

\_\_\_\_\_



\* X 8 0 7 7 6 0 1 2 4 \*

13. (continued)

- (b) Coral bleaching occurs when zooxanthellae leave the coral and the coral loses its colour and dies.

The sea temperatures in the summer and the percentage of the seabed covered by live coral were recorded around a coral reef from the year 2000.

The results are shown in the table.

Year	Summer sea temperature (°C)	Percentage of seabed covered by live coral
2000	27.8	37
2004	28.0	35
2008	28.5	30
2012	29.4	

Using evidence from the table, suggest the percentage of seabed that was covered by live coral in 2012 and justify your answer.

2

Percentage \_\_\_\_\_

Justification \_\_\_\_\_

\_\_\_\_\_  
 \_\_\_\_\_

[Turn over



14. Honeybees (*Apis mellifera*) are social insects that live in large colonies.

(a) Most of the bees in a colony are sterile and co-operate to raise the young in the colony.

(i) Name the type of bees that raise the young.

1

\_\_\_\_\_

(ii) Explain why this behaviour can be described as kin selection and state an advantage to the bees of raising the young.

2

Explanation \_\_\_\_\_

\_\_\_\_\_

Advantage \_\_\_\_\_

\_\_\_\_\_

(iii) Describe one other role of these sterile bees.

1

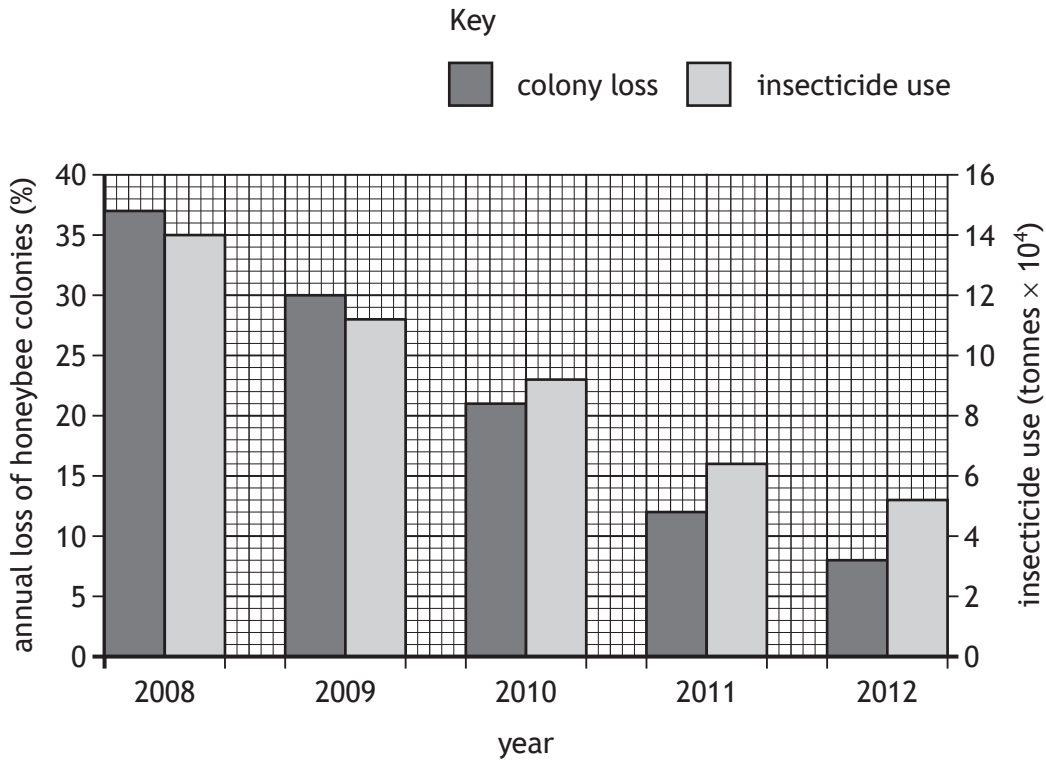
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\* X 8 0 7 7 6 0 1 2 6 \*

14. (continued)

(b) Insecticides are used to control crop pests. The graph shows the insecticide use and annual loss of honeybee colonies in the USA during each year from 2008 until 2012.



(i) At the beginning of 2009, the number of colonies in the USA was  $2.5 \times 10^6$ .

Calculate the number of colonies at the end of 2009.

*Space for calculation*

1

\_\_\_\_\_ colonies

(ii) Describe the relationship between insecticide use and annual loss of honeybee colonies between years 2008 and 2012.

1

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[Turn over



15. The Galapagos Islands have a high level of biodiversity. Non-native goats were introduced to the islands by humans. The goats out-competed the native Galapagos giant tortoises for food and spread rapidly across each island. As a result, the populations on some of the islands have been eliminated.

(a) (i) Using the information given, state why goats are considered to be an invasive species.

1

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(ii) Other than out-competing them for resources, give a reason why invasive species have a negative impact on native species.

1

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(iii) The bottleneck effect is occurring in the populations of tortoises on many of the Galapagos Islands.

Describe the impact of the bottleneck effect on these tortoise populations.

2

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(b) The population of giant tortoises on one of the islands has been increased by releasing breeding pairs of the same species.

State which component of biodiversity was increased by releasing breeding pairs and explain your answer.

2

Component \_\_\_\_\_

Explanation \_\_\_\_\_

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\* X 8 0 7 7 6 0 1 2 8 \*

16. Attempt either A or B. Write your answer in the space below and on pages 30 and 31.

A Write notes on metabolism under the following headings:

- (i) features of metabolic pathways and types of reactions 6
- (ii) roles of proteins embedded in membranes of cells. 2

OR

B Write notes on:

- (i) regulators 3
- (ii) thermoregulation by negative feedback in response to an increase in body temperature. 5

You may use labelled diagrams where appropriate.

[Turn over



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ADDITIONAL SPACE FOR ANSWER to question 16



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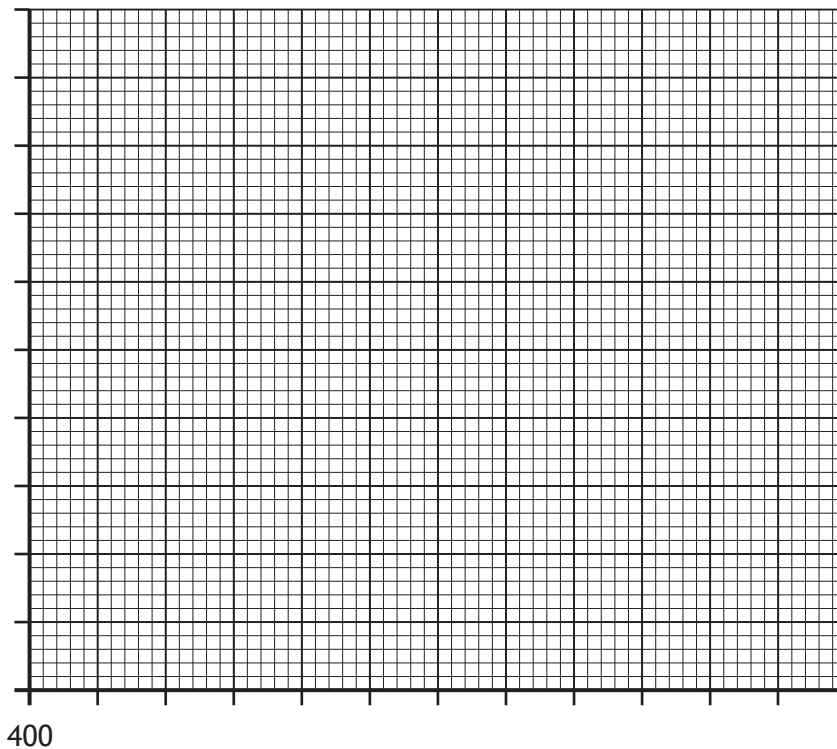
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\* X 8 0 7 7 6 0 1 3 1 \*

ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

Additional graph paper for question 10 (b)



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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK



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