

FOR OFFICIAL USE

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Total for
Sections
B & C

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X008/12/02

NATIONAL
QUALIFICATIONS
2012

THURSDAY, 24 MAY
1.00 PM – 3.30 PM

BIOTECHNOLOGY
HIGHER

Fill in these boxes and read what is printed below.

Full name of centre

--

Town

--

Forename(s)

--

Surname

--

Date of birth

Day Month Year

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Scottish candidate number

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Number of seat

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SECTION A (30 Marks)

Instructions for completion of Section A are given on page two.

For this section of the examination you must use an **HB pencil**.

SECTION B AND SECTION C (100 Marks)

- (a) All questions should be attempted.
(b) It should be noted that in **Section C** questions 1 and 2 each contain a choice.
- The questions may be answered in any order but all answers are to be written in the spaces provided in this answer book, and **must be written clearly and legibly in ink**.
- Additional space for answers will be found at the end of the book. If further space is required, supplementary sheets may be obtained from the Invigilator and should be inserted inside the **front** cover of this book.
- The numbers of questions must be clearly inserted with any answers written in the additional space.
- Rough work, if any should be necessary, should be written in this book and then scored through when the fair copy has been written. If further space is required, a supplementary sheet for rough work may be obtained from the Invigilator.
- Before leaving the examination room you must give this book to the Invigilator. If you do not, you may lose all the marks for this paper.



SECTION A

Read carefully

- 1 Check that the answer sheet provided is for **Biotechnology Higher (Section A)**.
- 2 For this section of the examination you must use an **HB pencil** and, where necessary, an eraser.
- 3 Check that the answer sheet you have been given has **your name, date of birth, SCN** (Scottish Candidate Number) and **Centre Name** printed on it.
Do not change any of these details.
- 4 If any of this information is wrong, tell the Invigilator immediately.
- 5 If this information is correct, **print** your name and seat number in the boxes provided.
- 6 The answer to each question is **either** A, B, C or D. Decide what your answer is, then, using your pencil, put a horizontal line in the space provided (see sample question below).
- 7 There is **only one correct** answer to each question.
- 8 Any rough working should be done on the question paper or the rough working sheet, **not** on your answer sheet.
- 9 At the end of the examination, put the **answer sheet for Section A inside the front cover of this answer book.**

Sample Question

What name is given to a culture of micro-organisms which contains more than one species of organisms?

- A Mixed
- B Pure
- C Simple
- D Complex

The correct answer is **A**—Mixed. The answer **A** has been clearly marked in **pencil** with a horizontal line (see below).



Changing an answer

If you decide to change your answer, carefully erase your first answer and, using your pencil, fill in the answer you want. The answer below has been changed to **D**.



SECTION A

All questions in this Section should be attempted.

Answers should be given on the separate answer sheet provided.

1. In a bacterial cell, DNA is found in the

- A nucleus only
- B plasmid only
- C chromosome and plasmid
- D nucleus and plasmid.

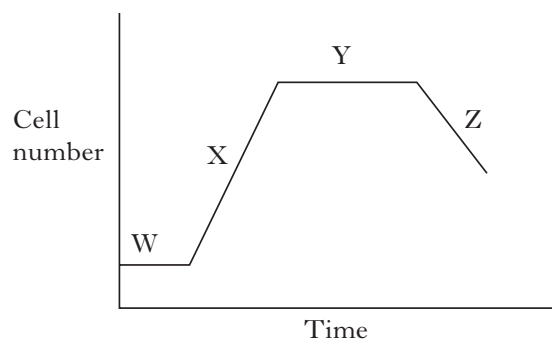
2. The enzyme used in the synthesis of cDNA is

- A endonuclease
- B ligase
- C polymerase
- D reverse transcriptase.

3. Which of the following are required for cDNA synthesis?

- A mRNA and DNA nucleotides
- B Single stranded DNA and DNA nucleotides
- C mRNA and RNA nucleotides
- D Single stranded DNA and RNA nucleotides

4. A viable count of bacteria grown in batch culture is shown below. Four stages of growth are labelled.



Which line in the table below correctly identifies each stage of the bacterial growth curve?

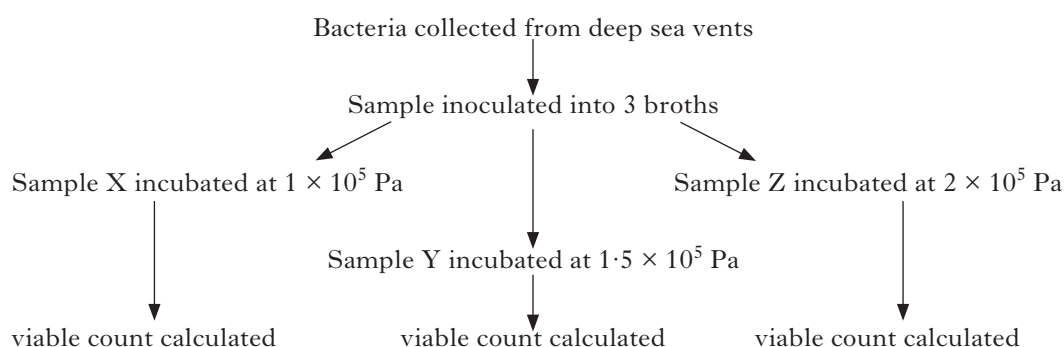
	<i>W</i>	<i>X</i>	<i>Y</i>	<i>Z</i>
A	log	lag	senescent	stationary
B	lag	log	senescent	stationary
C	log	lag	stationary	senescent
D	lag	log	stationary	senescent

5. A plasmid is a

- A non-coding region of DNA
- B circle of self-replicating DNA
- C cluster of genes with related functions
- D cloned fragment of DNA.

[Turn over

6. The experiment shown below was set up to investigate the effect of pressure on the growth of bacteria collected from deep sea vents. Normal atmospheric pressure is approximately 1×10^5 Pascals (Pa).



The results of the viable count are shown below.

Sample X	5.8×10^6 cells per cm^3
Sample Y	4.5×10^7 cells per cm^3
Sample Z	4.3×10^7 cells per cm^3

Which of the following conclusions is supported by the results?

- A The bacteria grow better at pressures greater than atmospheric pressure.
- B The bacteria grow better at atmospheric pressure.
- C High pressures inhibit bacterial growth.
- D The cell wall protects bacteria from high pressure.

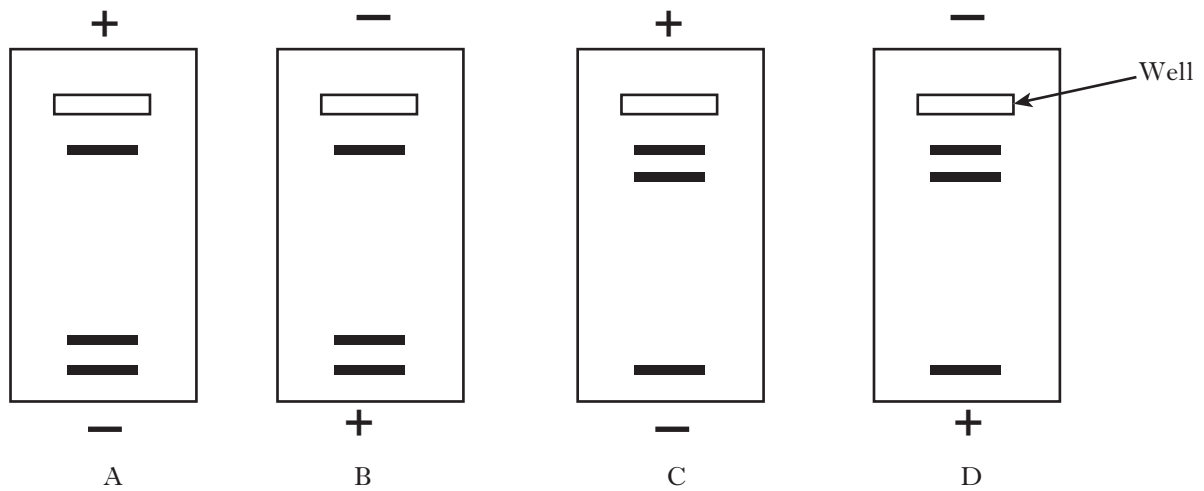
7. Which line in the table below identifies correctly features of a cloning vector?

	<i>Can accept foreign DNA</i>	<i>Can replicate in host cells</i>	<i>Can add sugars to proteins</i>
A	No	Yes	Yes
B	Yes	Yes	No
C	No	Yes	No
D	Yes	No	Yes

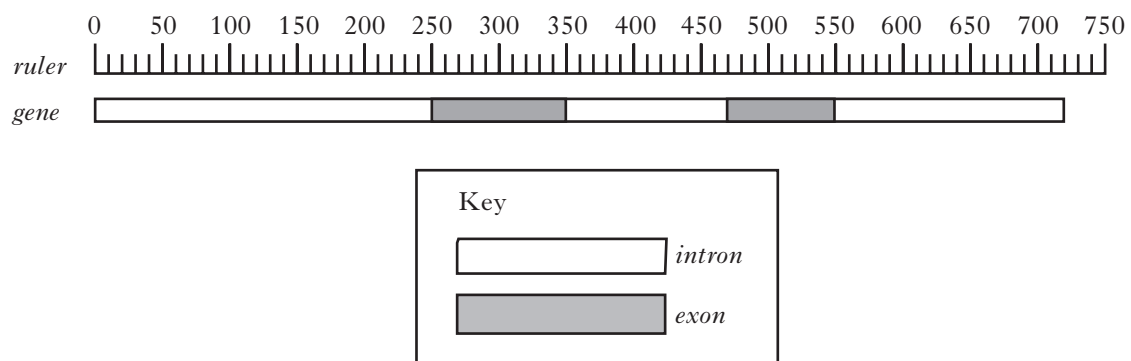
8. A population of yeast doubles every 30 minutes. If there are 10^3 yeast per cm^3 at the start of an experiment, how long would it take for the population to exceed 10^6 cells per cm^3 ?

- A 30 minutes
- B 3 hours 30 minutes
- C 5 hours
- D 10 hours

9. A DNA strand has been cut into three fragments of sizes 108 kbp, 65 kbp and 57 kbp. Which of the following gels shows the result of gel electrophoresis of these fragments?



10. The diagram below shows a eukaryotic gene containing introns and exons. A ruler showing sizes in base pairs is also shown.

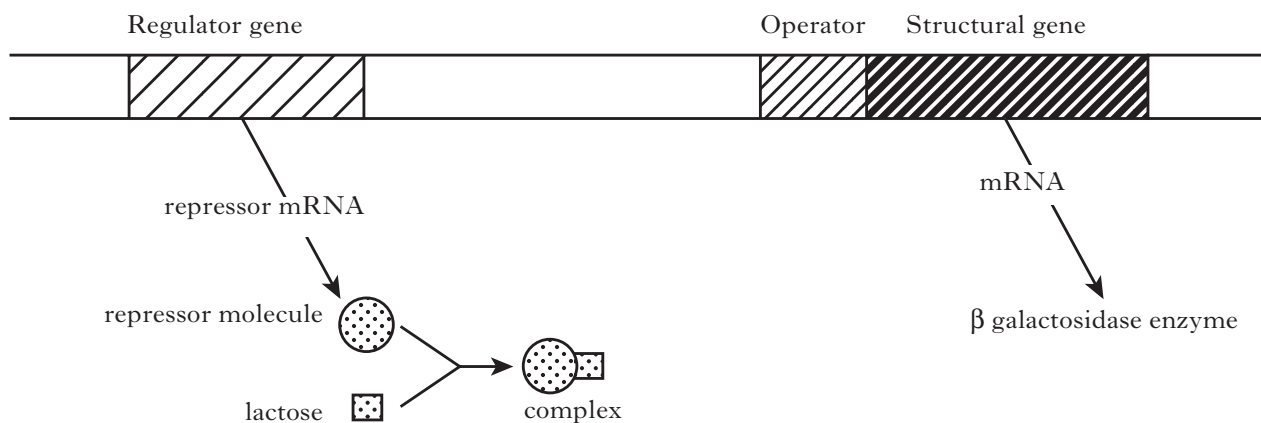


What length is the mature mRNA transcribed from this gene?

- A 180 base pairs
- B 540 base pairs
- C 550 base pairs
- D 720 base pairs

[Turn over]

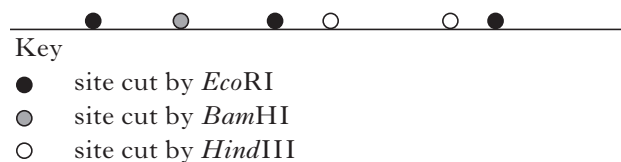
11. The diagram below represents events occurring in the bacterium *E.coli* in the presence of lactose.



As a direct result of these events the bacterium can

- A synthesise lactose
- B break down lactose
- C synthesise galactose
- D break down galactose.

12. The diagram below represents part of a DNA strand. The sites at which three different restriction enzymes cut the strand are shown.



Which line in the table below correctly shows the number of DNA fragments which would be obtained if the DNA strand shown on the diagram was cut with the restriction enzymes?

	<i>EcoRI</i>	<i>HindIII</i>	<i>EcoRI and BamHI</i>
A	2	2	3
B	2	2	5
C	4	3	3
D	4	3	5

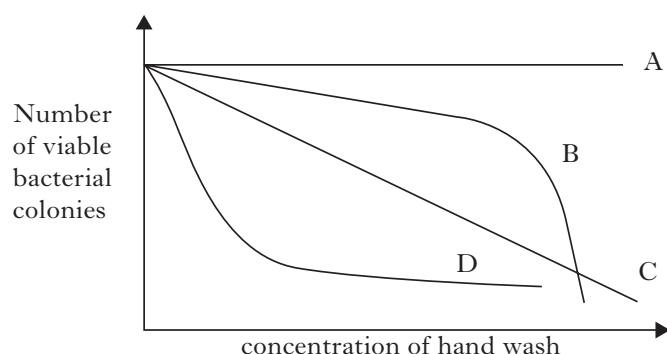
13. Gram positive bacteria stain a different colour to Gram negative bacteria when Gram stained. The reason for this is

- A Gram positive bacteria retain the purple dye
- B Gram negative bacteria do not retain the pink dye
- C Gram positive bacteria are destained by alcohol
- D Gram negative bacteria are stained by iodine.

14. Which of the following diagrams represents *Streptococcus*?

- A
- B
- C
- D

15. The graph below shows the effect of four antibacterial hand washes A, B, C and D on the growth of bacteria. Exposure to high concentrations of these antibacterial hand washes is suspected of causing skin irritation.



Which antibacterial hand wash would be recommended for regular laboratory use?

16. Which of the following procedures would be carried out to determine whether a bacterium produced amylase?

- A Inoculate nutrient broth and test for gas produced by fermentation of carbohydrates.
- B Inoculate nutrient broth and test for acid produced by fermentation of carbohydrates.
- C Inoculate starch agar plate and test with iodine solution.
- D Inoculate gelatine agar plate and test for change to liquid.

17. The table below shows the ingredients of 3 types of media for culturing bacteria.

<i>Medium 1</i>	<i>Medium 2</i>	<i>Medium 3</i>
Glucose	Powdered sulphur	Yeast extract
Na H ₂ PO ₄	NH ₄ Cl	Na H ₂ PO ₄
Na Cl	Ca Cl ₂	Na Cl
KH ₂ PO ₄	KH ₂ PO ₄	Peptone
Mg SO ₄	Mg Cl ₂	
Ca Cl ₂		

Which of these would be described as synthetic medium?

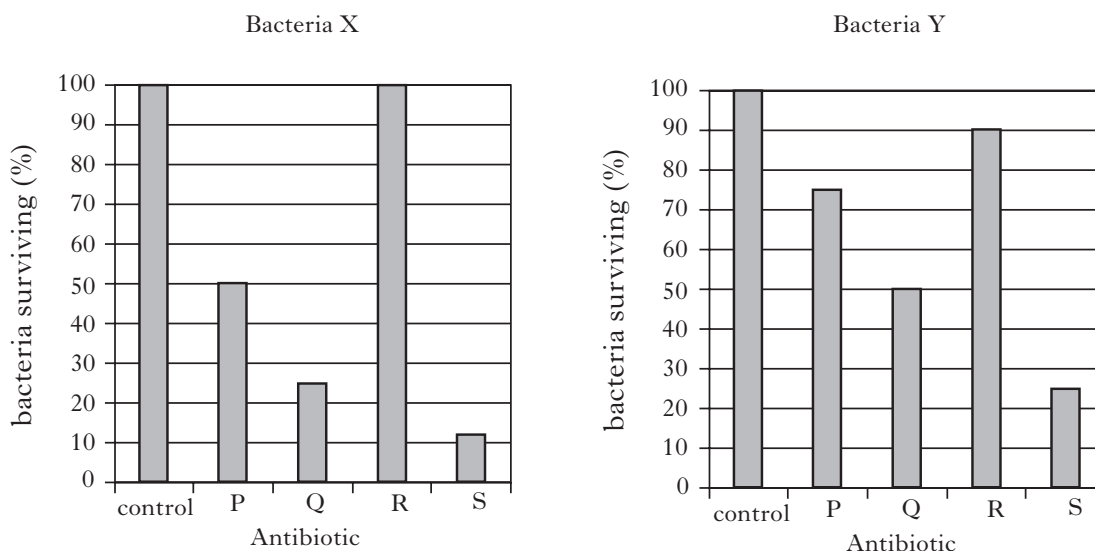
- A Medium 1 only
- B Medium 2 only
- C Medium 3 only
- D Medium 1 and medium 2 only

18. Which of the following statements is true for somatic cell cloning?

- A DNA is donated from a differentiated cell.
- B DNA is donated from an undifferentiated cell.
- C Used to increase the rate of reproduction.
- D Used to produce a transgenic animal.

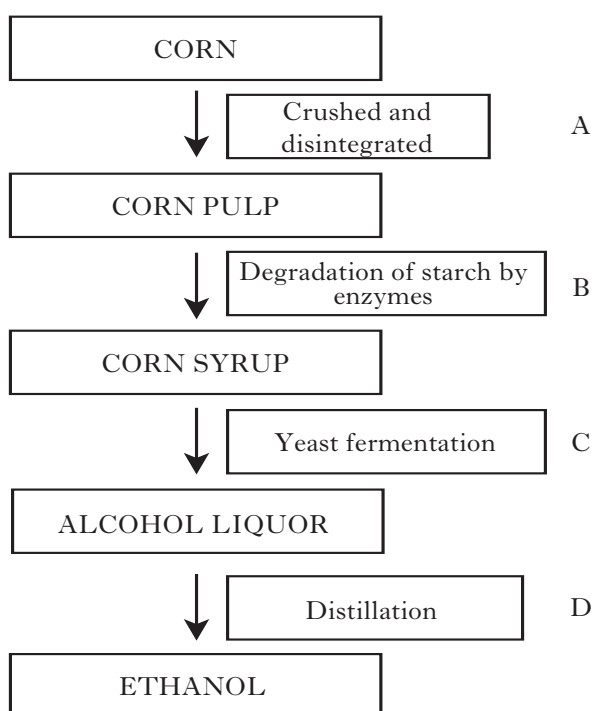
[Turn over

19. Two different types of bacteria, X and Y, were incubated with four different antibiotics, P, Q, R and S. The percentage number of bacteria surviving after 3 hours is shown in the graphs below.



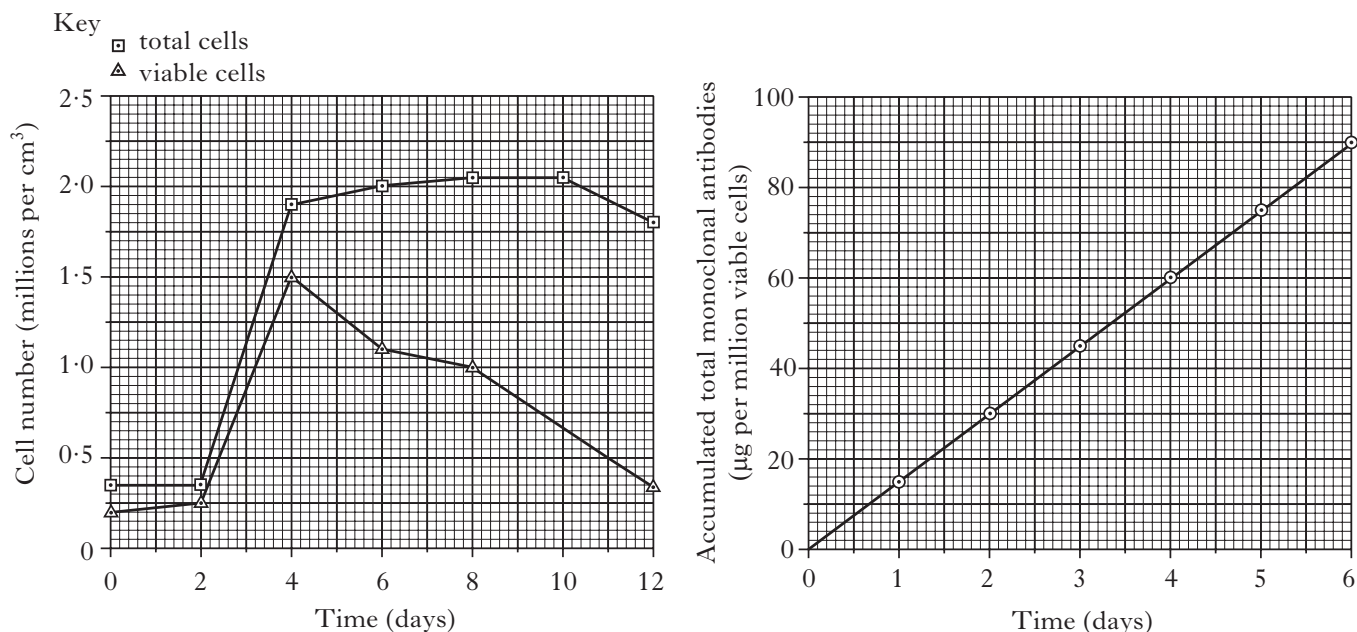
Which of the following can be concluded from these results?

- A Bacteria X is less sensitive to antibiotic P than bacteria Y.
 - B Bacteria X is more resistant to antibiotic Q than bacteria Y.
 - C Bacteria Y is more resistant to antibiotic R than bacteria X.
 - D Bacteria Y is less sensitive to antibiotic S than bacteria X.
20. The diagram below shows a flow chart for the production of ethanol from corn.



At which stage would a laboratory model be used to investigate the optimum conditions for the rate at which nutrients are used up?

21. Hybrid cells producing monoclonal antibodies were grown over a 12 day period. The number of cells and the accumulated mass of monoclonal antibodies produced are shown in the graphs below.



From these results the total accumulated monoclonal antibody per cm³ on day 6 is

- A 31.5 µg
 - B 99 µg
 - C 162 µg
 - D 180 µg.
22. The production of monoclonal antibodies involves the creation of a hybrid cell. This hybrid cell is created by fusing
- A a macrophage and a cancer cell
 - B a cancer cell and a β-lymphocyte
 - C an antibody and a macrophage
 - D an antibody and a β-lymphocyte.

[Turn over

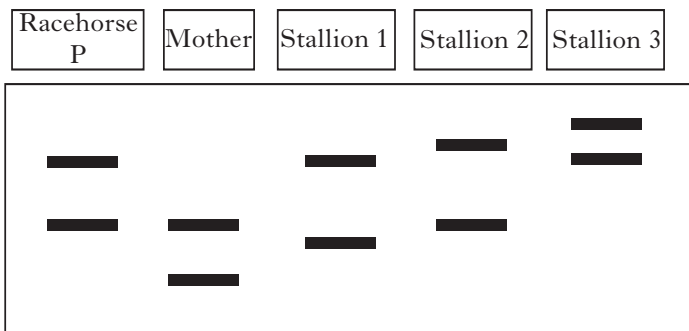
23. The steps involved in the production of a hepatitis vaccine by genetically modified yeast cells are shown below.

1. Yeast cells secrete the viral surface antigen.
2. DNA coding for viral surface antigens isolated.
3. Viral surface antigens purified and used as a vaccine.
4. DNA coding for viral surface antigens cloned in yeast cells.

Which of the following is the correct sequence of these steps?

- A 2 4 1 3
- B 1 3 4 2
- C 2 1 4 3
- D 1 4 3 2

24. DNA profiling was carried out to establish the pedigree of a racehorse.



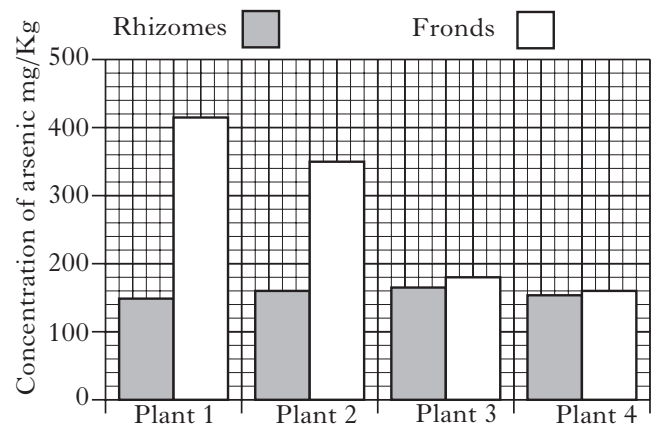
Based on the results shown here, which of the stallions could be the father of Racehorse P?

- A Stallion 1 only
- B Stallion 2 only
- C Stallion 1 or Stallion 3 only
- D Stallion 1, Stallion 2 or Stallion 3

25. Before a DNA profile is carried out, the samples of DNA are treated with

- A ligase
- B endonuclease
- C alkali
- D a radioactive probe.

26. The graph below shows the concentration of arsenic in rhizomes and fronds of fern plants in a bioremediation study.



In plant 2 how much more arsenic is there in the fronds compared to the rhizomes expressed as a percentage?

- A 55%
- B 115%
- C 119%
- D 195%

27. An experiment was carried out to determine the optimum pH for activity of lysozyme. The results are shown below.

<i>pH</i>	<i>Enzyme activity</i> (arbitrary units)
9	0.01
8	0.08
7	0.21
6	0.64
5	1.13
4	1.81

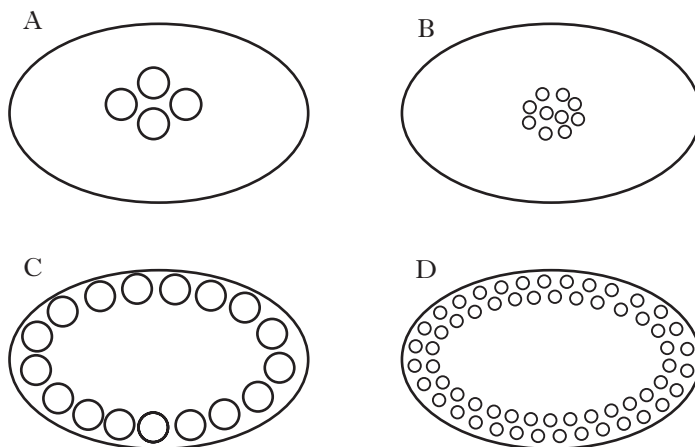
Which of the following conclusions can be drawn **from these results**?

- A The optimum pH for lysozyme activity is pH4.
- B Enzymes work best at neutral pH.
- C Lysozyme is inhibited at alkaline pH.
- D Enzymes are denatured at acid pH.

28. Which of the following is a use of lysozyme?

- A Used to disrupt yeast cells
- B Used to clarify fruit juice
- C Used in the manufacture of feedstock
- D Used to remove fibrin clots

29. Which of the following designs of sparger would be most efficient at introducing oxygen into a fermenter?



30. The part of a biosensor which would detect a pollutant is made of

- A protein
- B carbohydrate
- C lipid
- D nucleic acid.

**Candidates are reminded that the answer sheet for Section A MUST be returned
INSIDE the front cover of this answer book.**

[Turn over for Section B on Page twelve]

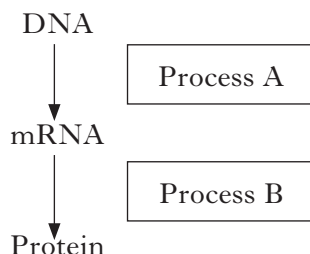
SECTION B

Marks

All questions in this section should be attempted.

All answers must be written clearly and legibly in ink.

1. Protein synthesis in a fungal cell can be summarised as shown below.



- (a) (i) Complete the table by stating the name of each process and the part of the cell where it takes place.

	<i>Name of process</i>	<i>Part of cell</i>
Process A		
Process B		

2

- (ii) tRNA is also involved in protein synthesis.

What is the function of tRNA?

1

- (b) An amino acid chain is formed in process B.

- (i) Name the bond that links amino acids together.

1

In order to function properly, proteins have to fold into more ordered secondary and tertiary structures.

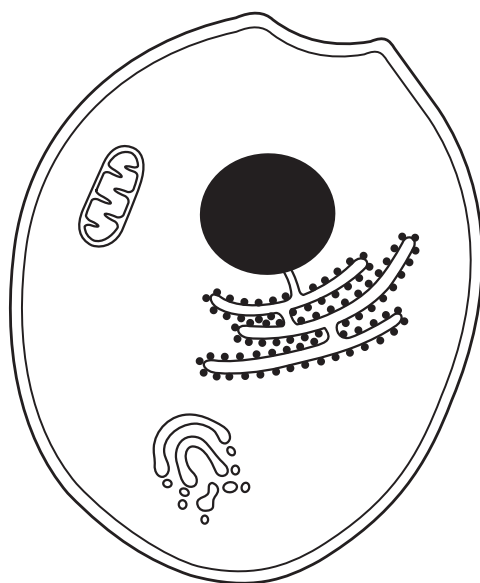
- (ii) Describe how the amino acid chain forms a **secondary** structure.

1

Marks

1. (continued)

(c) The diagram below represents a typical unicellular fungus.



- (i) Add a label to the diagram to show the Golgi apparatus. 1
- (ii) Suggest why a fungal cell would have a large quantity of Golgi apparatus.

1

[Turn over

Marks

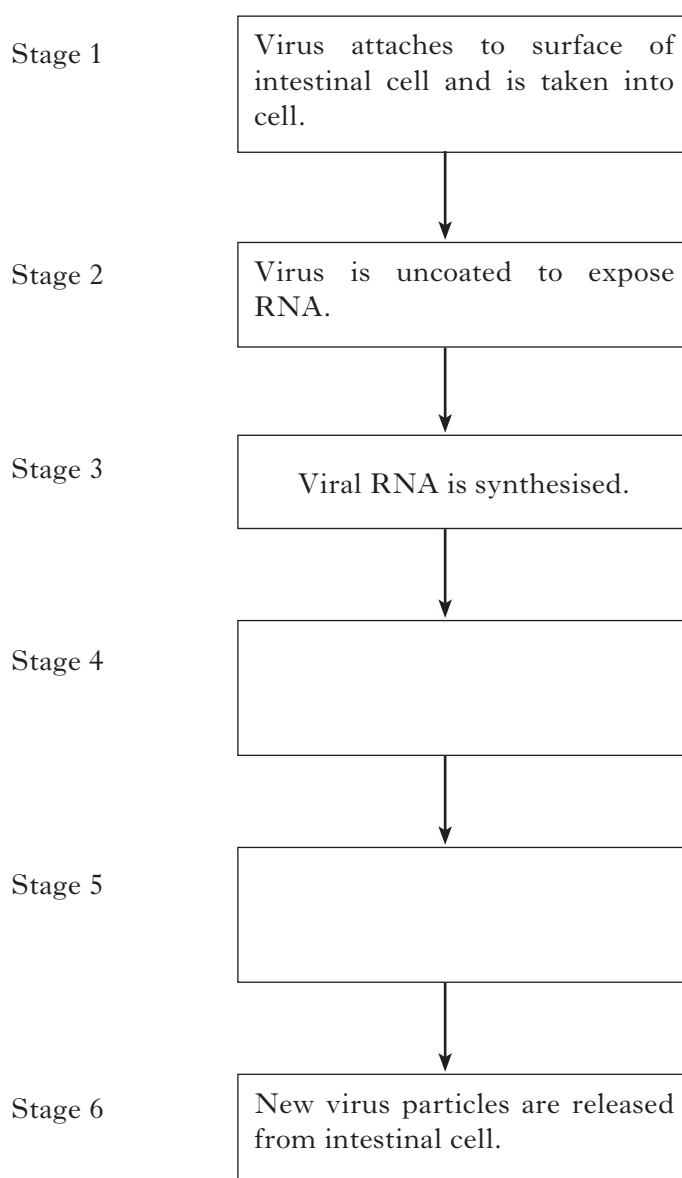
2. Cases of “winter vomiting virus” are believed to be caused by a single-stranded RNA virus called norovirus. This virus is described as being non-enveloped.

(a) Name the outer layer of such non-enveloped viruses.

1

- (b) After this virus infects the cells lining the walls of the intestine it then replicates.

Complete the flow chart to describe what happens at stages 4 and 5 during the replication of the virus.



2

*Marks***2. (continued)**

- (c) Electron microscopy studies show that noroviruses are approximately 0·0029 micrometres in size. Express this number in nanometres.

1 micrometre = 1000 nanometres

Space for calculation

_____ nanometres

1

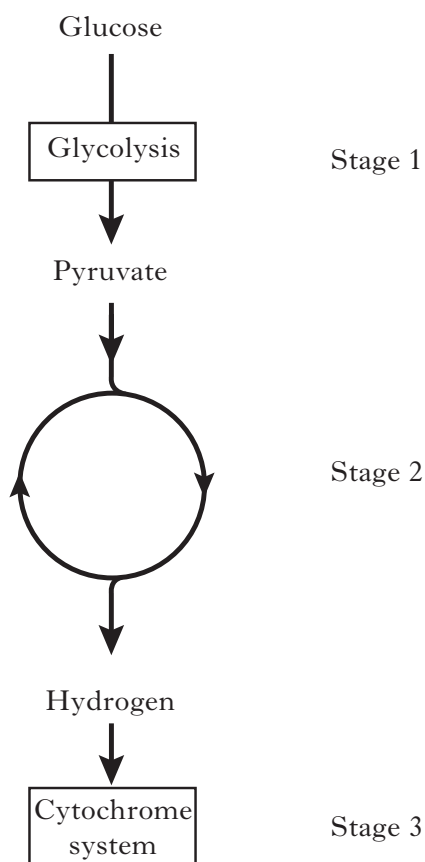
- (d) Give an example of a beneficial use of viruses.

1

[Turn over

Marks

3. Yeast can metabolise glucose as a source of energy. The stages involved in energy release from this glucose are shown below.



- (a) Name stage 2.

1

- (b) Which of these stages would occur in the absence of oxygen?

1

- (c) Give the **exact** location of stage 3 in a yeast cell.

1

- (d) How is hydrogen transferred from stage 2 to the cytochrome system?

1

- (e) How many ATP molecules are produced per glucose molecule under aerobic conditions?

1

- (f) What term is used to describe micro-organisms that can respire in the presence and absence of oxygen?

1

[Turn over for Question 4 on *Page eighteen*]

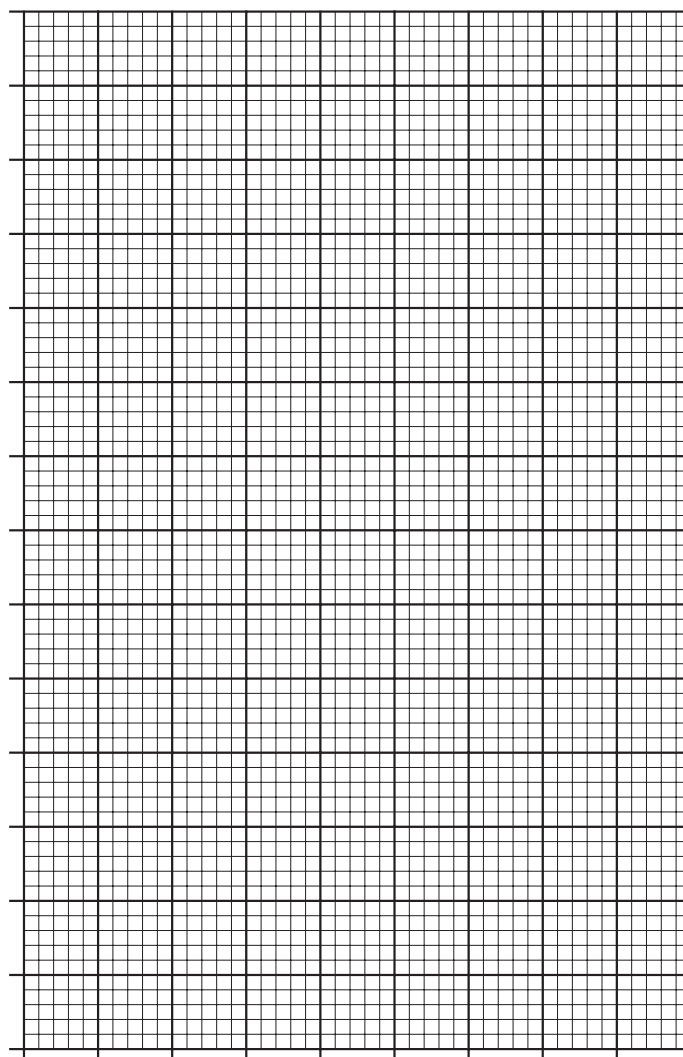
Marks

4. Sourdough is a traditional bread with its characteristic taste due to the combination of *Candida* yeast and *Lactobacilli* bacteria used in its production.

The effect of temperature on the growth of each of these micro-organisms in liquid culture was investigated and the results are shown in the table below.

Temperature (°C)	Cell growth (relative increase in mass per hour)	
	<i>Candida</i>	<i>Lactobacillus</i>
5	0.00	0.00
10	0.05	0.05
15	0.11	0.16
20	0.23	0.29
25	0.33	0.50
30	0.40	0.66
35	0.07	0.48
40	0.00	0.14

- (a) (i) Plot line graphs of cell growth against temperature for **each** micro-organism.
(Additional graph paper, if required, can be found on *page thirty-six*)



Marks

4. (a) (continued)

- (ii) Using the data for both micro-organisms, state **one** conclusion that could be drawn from this investigation.

1

- (iii) Doubling time can be calculated by using the formula

$$\text{Doubling time (hours)} = \frac{0.69}{\text{relative increase in mass per hour}}$$

Use this equation and the data provided in the table to determine the doubling time of *Candida* at 30 °C.

Space for calculation

1

- (b) The products of fermentation allow the dough to rise and affect the flavour of the bread. Name the products of the anaerobic fermentation carried out by *Candida* and *Lactobacillus*.

Candida _____

Lactobacillus _____

2

- (c) (i) State **two** variables that should be controlled when setting up this experiment.

1 _____

2 _____

2

- (ii) Explain why cultures of both organisms were grown to exponential phase before use in this experiment.

1

- (d) Describe a further experiment that could be done to more accurately determine the optimum temperature for cell growth.

2

Marks

5. Mannitol Salt agar (MSA) is both a selective and differential medium. It contains 7.5% sodium chloride, mannitol as a carbon source and phenol red indicator.

The sodium chloride prevents the growth of most organisms other than *Staphylococcus*. Pathogenic *Staphylococcus aureus* ferments mannitol to produce acid, other *Staphylococcus* species do not. The phenol red turns yellow when the pH drops below neutral.

- (a) Complete the following table by putting a tick (✓) in the box to show which components of the medium are selective and which are differential.

<i>Component</i>	<i>Selective</i>	<i>Differential</i>
Mannitol		
Phenol red		
Sodium chloride		

2

- (b) In order to determine the number of *Staphylococcus aureus* in a mixed culture of bacteria, the culture was diluted 1 in 10^6 and 0.1 cm^3 was spread on an MSA plate. After incubating for 24 hours, the number of colonies on the plate was counted.

The results are shown below:

37 yellow colonies

14 red colonies

- (i) How many colonies on the plate were pathogenic *Staphylococcus aureus*?
Justify your answer.

Number of colonies _____

Justification _____

1

- (ii) Calculate the number of *Staphylococcus aureus* cells in 1 cm^3 of the original culture.

Space for calculation

_____ per cm^3

1

*Marks***5. (b) (continued)**

- (iii) From the information given, why is it not possible to calculate the total number of cells in the original mixed culture?

1

- (c) *Micrococcus*, a bacterium similar to *Staphylococcus*, has cytochrome c, whereas *Staphylococcus* does not. What test can be used to distinguish between these two micro-organisms?

1**[Turn over]**

Marks

6. A bacteriologist spilt 10 cm^3 of bacterial broth culture on the laboratory bench. In order to deal with the spillage a code of practice was consulted.

(a) (i) What type of risk assessment was the bacteriologist following?

1

(ii) Apart from a lab coat, name **two** items of protective equipment the bacteriologist should use when cleaning up the spillage.

1 _____

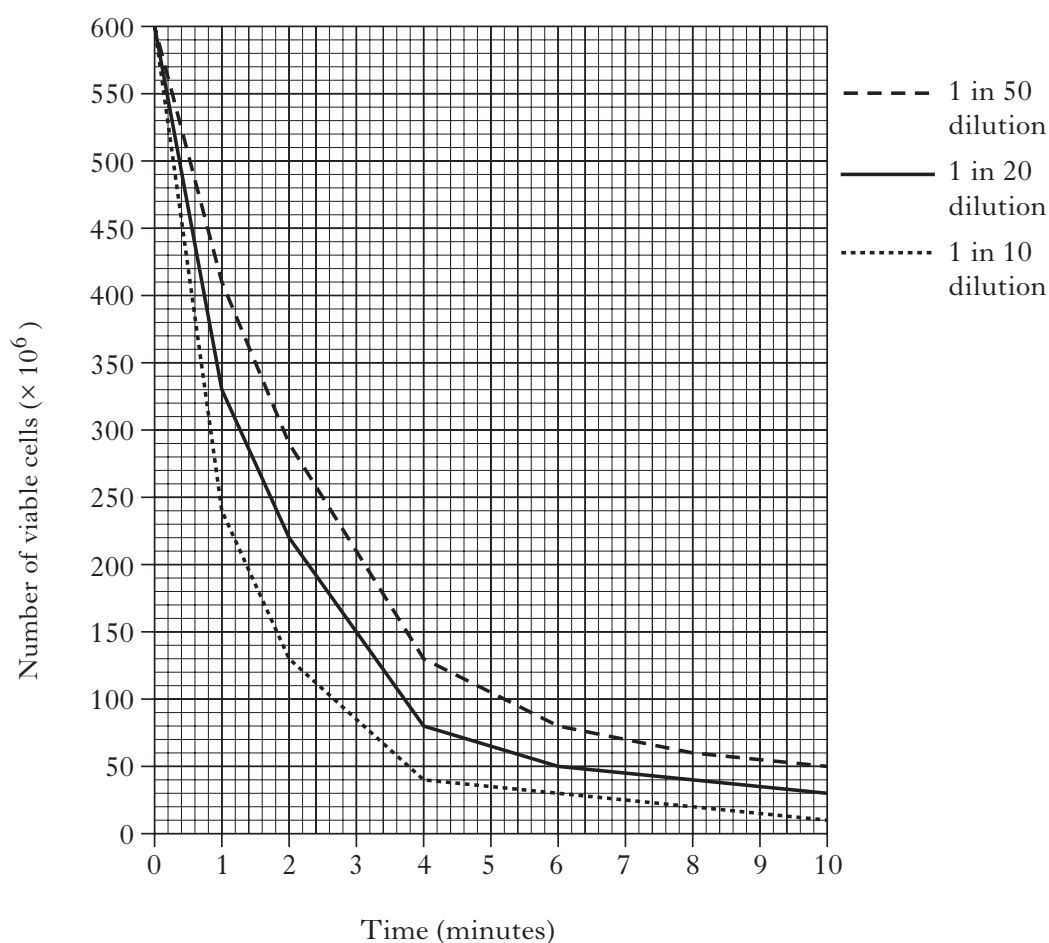
2 _____

1

(iii) How would the contaminated materials from the spillage be disposed of safely?

1

One of the steps in dealing with the spillage involves using a disinfectant. Different dilutions of the disinfectant were tested by adding an equal volume of each dilution to a known concentration of *E coli*. The number of viable cells surviving was measured at set time intervals as shown in the graph below.



Marks

6. (continued)

(b) A spillage can be cleared up when the number of viable cells surviving is below 80×10^6 .

- (i) If the disinfectant is left on the spillage for 5 minutes, which dilution would be the most appropriate to use?

1

- (ii) A control solution without disinfectant was also included in the experiment. Give a reason why this control is necessary.

1

- (iii) Explain why viable cell number rather than total cell number was measured.

1

- (iv) From the data shown in the graph, is this disinfectant biostatic or biocidal? Tick (✓) the correct box.

biostatic

☐

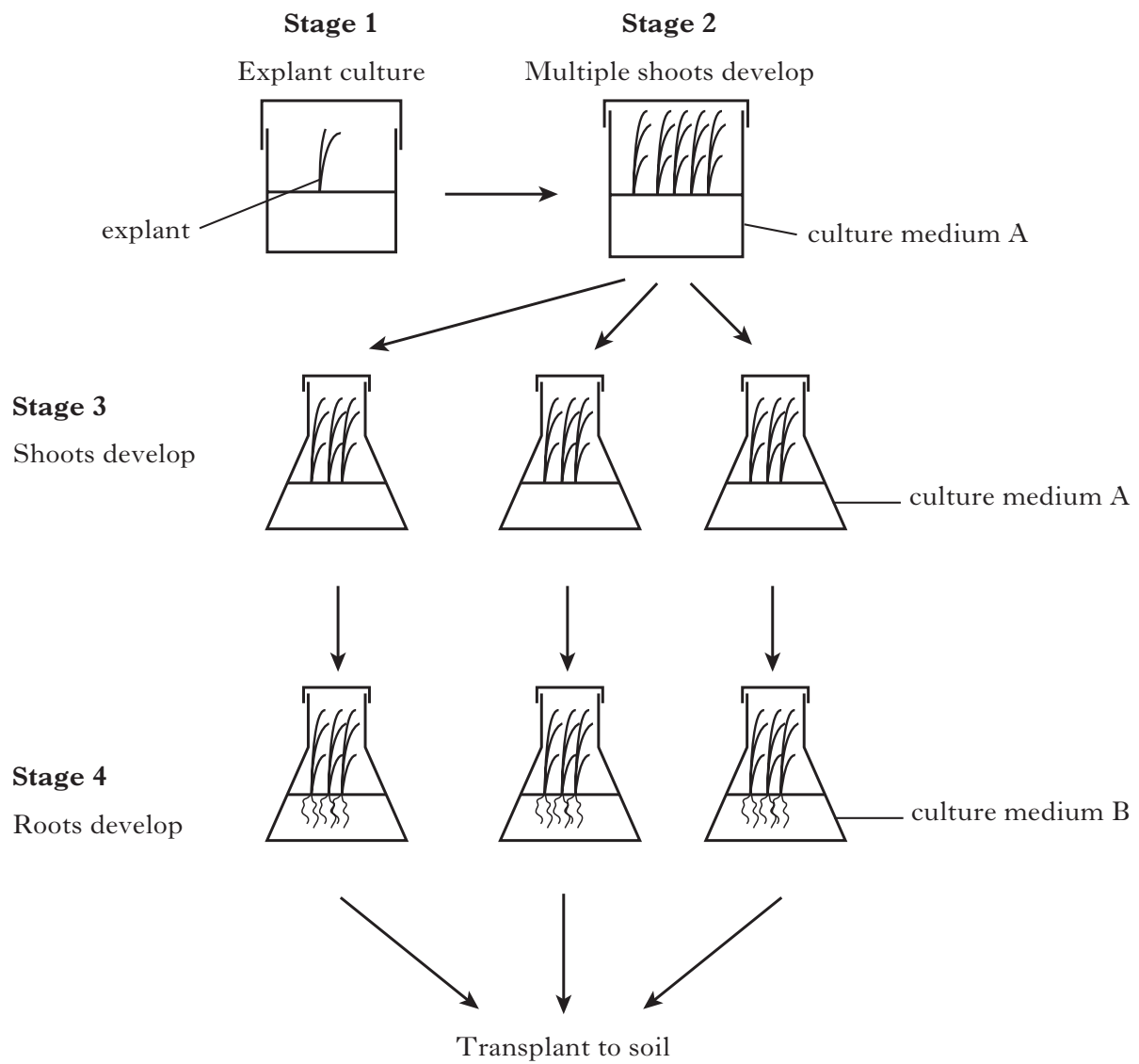
biocidal

☐

Give a reason for your answer.

1**[Turn over]**

7. Rice is the world's most important food crop. Micropropagation techniques are routinely used for mass production of rice plants, as shown below.



Marks

7. (continued)

- (a) The explants were taken from the shoot tips of the original plant.
What name is given to this part of the plant?

1

- (b) (i) Explain why the explant would be dipped in disinfectant before placing in the culture medium, at Stage 1.

1

- (ii) Explain why a carbon source must be included in the culture medium.

1

- (iii) Using the information in the diagram, suggest how culture medium A differs from culture medium B.

1

- (iv) What could be used to control the pH of the culture medium?

1

- (c) During micropropagation, samples of the rice plants were found to be no longer genetically identical to the original explant.

What process has caused this genetic change?

1**[Turn over**

Marks

8. The USA has a target to produce 35 billion gallons of biofuel per year from renewable sources of biomass. Most biofuel in the USA is presently produced from corn biomass.

The table below shows the result of field trials comparing corn and *Miscanthus* as an alternative source of biomass for biofuel production.

	<i>Harvestable biomass (tons per acre)</i>	<i>Ethanol produced (gallons per ton)</i>	<i>Area required to produce 35 billion gallons of biofuel (million acres)</i>	<i>% harvested US cropland required to produce 35 billion gallons</i>
Corn	7.8	97	7.2	14.0
<i>Miscanthus</i>	13.2	91	4.8	9.3

- (a) (i) Using the information in the table, justify the choice of *Miscanthus* for biofuel production.

2

- (ii) From the data shown give **one** advantage of using corn for biofuel production.

1

The bar graph, on *Page twenty-seven*, shows the biomass produced from each crop at three different test sites.

- (b) (i) Use the table and the graph to calculate how many more gallons of biofuel could be produced from an acre of *Miscanthus* at Site 3 than at Site 1.

Space for calculation

_____ gallons

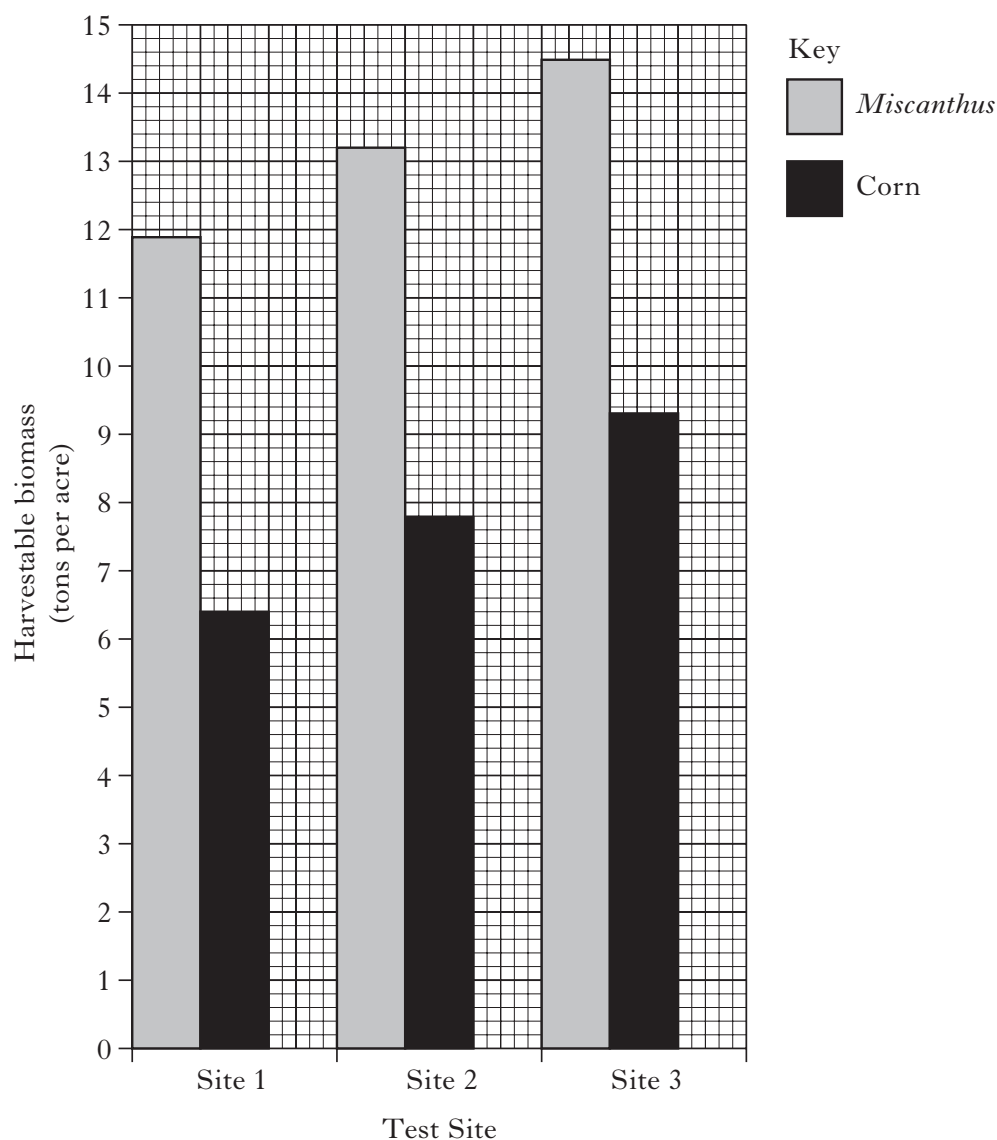
1

- (ii) Suggest **two** factors that might account for the difference in yield between sites.

1

Marks

8. (continued)



- (c) Predict how the area of land used to grow crops for biofuel might change in the future. Give a reason for your answer.

Prediction _____

Reason _____

1

- (d) The production of biofuel involves breaking down plant cell walls.

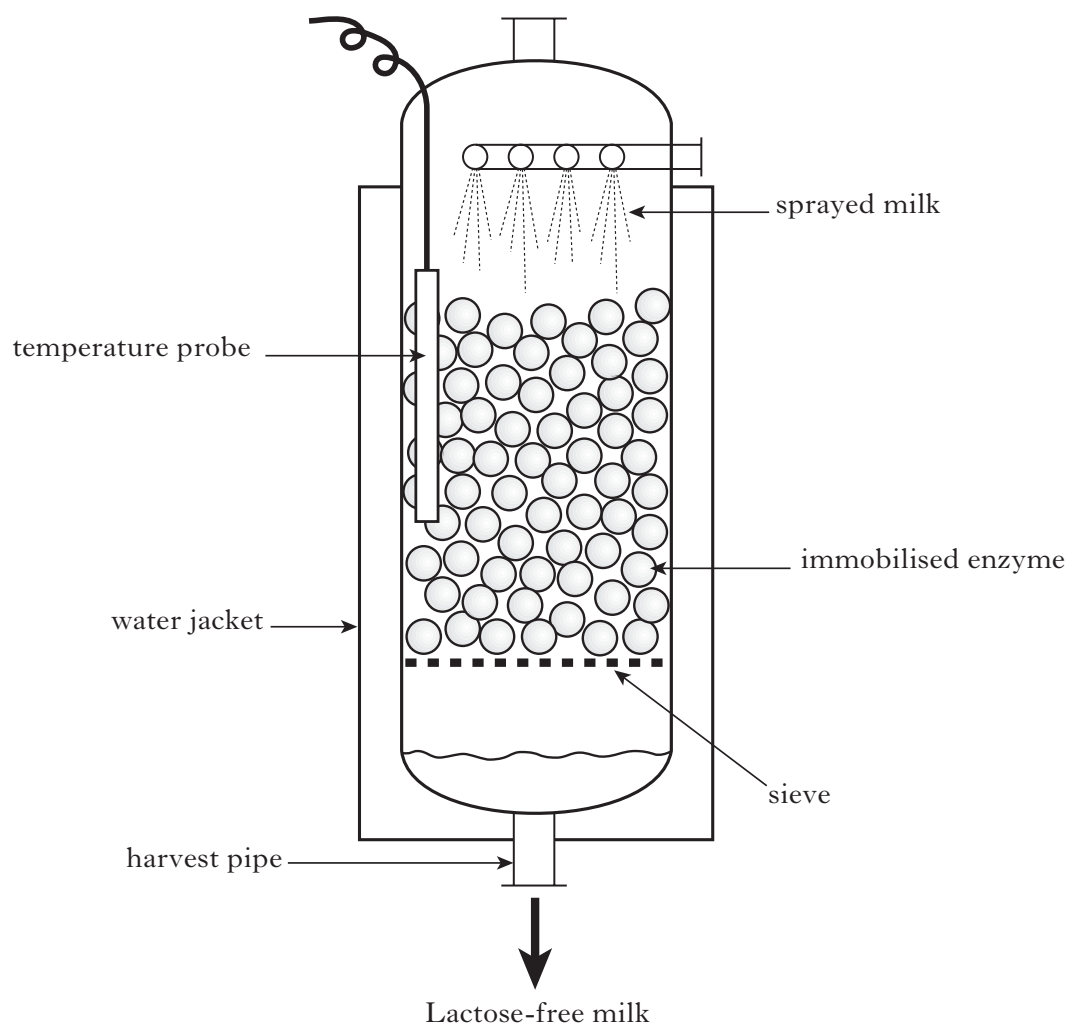
Name the enzyme used in this process.

1

[Turn over

Marks

9. Lactose-free milk can be produced by treating milk with an enzyme immobilised within a gel-like matrix. A pilot plant for lactose-free milk production is shown in the diagram below. Milk flows through the vessel and lactose-free milk is produced.



- (a) (i) What type of immobilisation uses a gel-like matrix?
- _____ 1
- (ii) State **one** advantage of using immobilised enzymes in the downstream processing of this product.
- _____ 1
- (iii) Explain why the milk is sprayed rather than poured in as a single stream.
- _____ 1

Marks

9. (continued)

- (b) Explain why the production of lactose-free milk is described as a continuous flow process.

1

- (c) At this pilot plant stage the optimum temperature for the process was measured.

- (i) Which part of the vessel labelled in the diagram would be used to control the temperature?

1

- (ii) Why was it important to control the temperature in this process?

1

- (iii) Apart from temperature and cost, name **two** other factors that would be established at the pilot plant stage.

1

2

2

- (d) Suggest an experiment that could be carried out to test whether immobilisation had affected enzyme activity.

1

[Turn over

Marks

10. Penicillin is an antibiotic produced by the filamentous fungus *Penicillium chrysogenum*. The fungus can be grown in large scale fermenters. After several days, the fermentation is stopped and the antibiotic extracted.

(a) Which method could be used to extract:

- (i) the fungus from the liquid medium;

1

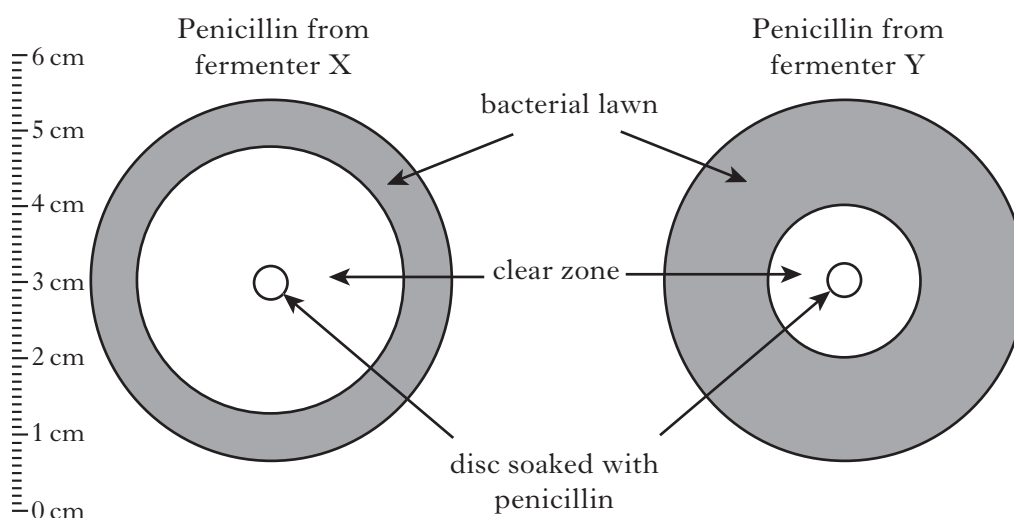
- (ii) the penicillin from the liquid medium?

1

(b) What term is used to describe products that are secreted into the medium by micro-organisms?

1

(c) The diagram below shows the results of an experiment on the antibacterial activity of penicillin from two separate fermenters.



- (i) Measure the diameter of the clear zone produced by each sample of penicillin.

Penicillin from fermenter X _____

Penicillin from fermenter Y _____

1

- (ii) Calculate the simplest whole number ratio of the diameter of the clear zones produced by the penicillin from fermenter X and fermenter Y.

Space for calculation

_____ : _____
fermenter X : fermenter Y

1

*Marks***10. (continued)**

- (d) Explain why penicillin is more effective against Gram positive than Gram negative bacteria.

1

- (e) Which material is routinely used to construct industrial fermenters?

1

- (f) Penicillin production is an aerobic process carried out in an airlift fermenter. The air pumped into the fermenter is passed through a filter.

- (i) Explain why the air is filtered.

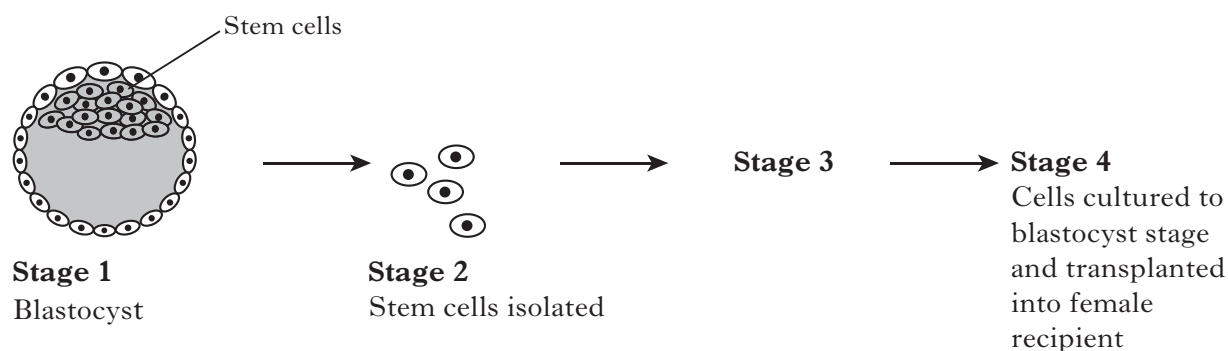
1

- (ii) The fermenter does not contain any paddles. Give a reason for this type of design.

1**[Turn over**

Marks

11. Embryo cloning is a technique that is used in animal breeding. The diagram below shows some of the stages in this process.



- (a) (i) Explain why cells used for embryo cloning are taken from a blastocyst.

1

- (ii) Give a potential medical use of stem cells.

1

- (b) State **two** reasons why animal breeders would use the technique of embryo cloning.

1 _____

2 _____

2

- (c) (i) The stem cells at **Stage 2** are manipulated further in **Stage 3**.
What name is given to the technique used at **Stage 3**?

1

- (ii) What term is used to describe the recipient female at **Stage 4**?

1

Marks

SECTION C**Both questions in this section should be attempted.****Note that each question contains a choice.****Questions 1 and 2 should be attempted on the blank pages which follow.****All answers must be written clearly and legibly in ink.****Supplementary sheets, if required, may be obtained from the Invigilator.****Labelled diagrams may be used where appropriate.****1. Answer either A or B.****A.** Describe the applications of the following micro-organisms in agriculture:(a) *Agrobacterium tumefaciens*;**5**(b) *Bacillus thuringiensis*.**5****(10)****OR****B.** Describe the production and uses of transgenic animals under the following headings:

(a) production of transgenic animals;

2

(b) use of transgenic animals to produce medical products;

3

(c) advantages and disadvantages over the use of micro-organisms.

5**(10)****In Question 2 ONE mark is available for coherence and ONE mark is available for relevance.****2. Answer either A or B.****A.** Give an account of the similarities and differences between a bacterial cell and a yeast cell.**(10)****OR****B.** Give an account of the cells of the immune system and their functions in innate and acquired immunity.**(10)***[END OF QUESTION PAPER]*

SPACE FOR ANSWERS

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SPACE FOR ANSWERS

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ADDITIONAL GRAPH PAPER FOR USE IN QUESTION 4 (a) (i)

