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EDEXCEL A LEVEL BIOLOGY B: QUESTIONS BY TOPIC

Microbiology and Pathogens (6)

A Level Biology B Topic 6

37 questions · 404 marks · Mark schemes included

Pearson Edexcel AS (8BI0) and A Level (9BI0) Biology B, June 2016 - June 2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic; within each sub-topic they run from the lowest mark tariff to the highest.

Click any heading or question row below to jump straight to it.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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6(a) MICROBIAL CULTURE AND GROWTH		9 questions · 106 marks	4
1. Q2	<i>also Topic 1</i>	A Level Paper 1 June 2019	6
2. Q3	<i>also Topic 2</i>	AS Paper 1 June 2024	8
3. Q8		A Level Paper 1 June 2018	11
4. Q5	<i>also Topic 2</i>	A Level Paper 3 June 2023	12
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6(d) ANTIBIOTICS AND ANTIBIOTIC RESISTANCE

7 questions · 77 marks

90

31.	Q2	<i>also Topic 1</i>	AS Paper 1 June 2018	7	91
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QUESTIONS

37 questions · 404 marks · grouped by sub-topic, lowest tariff first



SUB-TOPIC 6(a)

MICROBIAL CULTURE AND GROWTH

9 questions in this sub-topic · 106 marks · lowest tariff first



2 Bacteria were cultured in two different types of medium.

One medium contained glucose as the energy source and the other contained sucrose.

The same molar concentrations of glucose and sucrose were used.

(a) Which row of the table identifies these sugars?

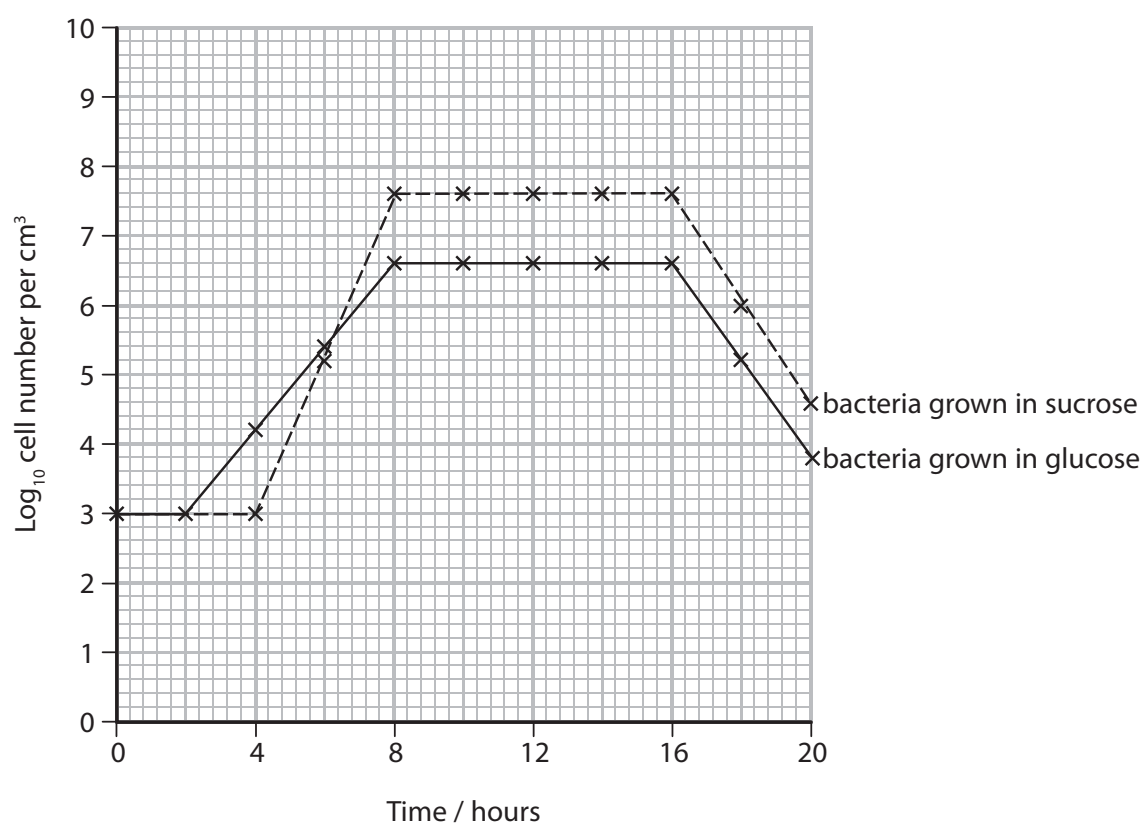
(1)

	Glucose	Sucrose
☐ A	monosaccharide	monosaccharide
☐ B	monosaccharide	disaccharide
☐ C	disaccharide	disaccharide
☐ D	disaccharide	monosaccharide

(b) Bacteria were grown in each medium for 20 hours.

Every two hours, the numbers of bacteria were determined using dilution plating and an optical method (turbidity).

The graph shows the results from the dilution plating.



- (i) Calculate how many times faster the bacteria in sucrose reproduce than the bacteria in glucose, during the log phase.

(2)

Answer

- (ii) Analyse the data to explain why the growth curve for sucrose is different from the growth curve for glucose.

(2)

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- (iii) On the graph, draw a curve to show the number of bacteria grown in glucose as determined by the optical method.

(1)



3 *Bacillus subtilis* and *Pseudomonas aeruginosa* are two types of bacteria.

(a) (i) Which pair of structures is found in these bacteria?

(1)

- ☐ A nucleoid and 70S ribosomes
- ☐ B nucleoid and 80S ribosomes
- ☐ C nucleus and 70S ribosomes
- ☐ D nucleus and 80S ribosomes

(ii) Name **three other** structures that are surrounded by the cell wall of bacteria.

(2)

- 1
- 2
- 3

(b) A scientist determined the thickness of the cell wall of these bacteria.

The thickness of the cell wall of *B. subtilis* is 55.4 nm and the thickness of the cell wall of *P. aeruginosa* is 2.4 nm.

(i) Calculate the ratio of the thickness of the cell wall of *B. subtilis* to that of *P. aeruginosa*.

Give your values to **two** significant figures.

(1)

Answer



(ii) Some antibiotics affect only Gram positive bacteria.

Explain which of *B. subtilis* or *P. aeruginosa* will be affected by these types of antibiotics.

(2)

(c) *Bacillus subtilis* was grown in a culture. At the start the culture contained 6×10^3 cells and after two hours the culture contained 1.7×10^5 cells.

Calculate the mean rate of increase in the number of bacteria in this culture.

Give your answer in cells per minute.

(2)

Answer cells per minute

(Total for Question 3 = 8 marks)



8 *Salmonella* are Gram negative bacteria found in the large intestine of humans.

(a) Which is the correct statement about *Salmonella*?

(1)

- ☐ A *Salmonella* has a thick peptidoglycan cell wall and produces endotoxins
- ☐ B *Salmonella* has a thick peptidoglycan cell wall and produces exotoxins
- ☐ C *Salmonella* has a thin peptidoglycan cell wall and produces endotoxins
- ☐ D *Salmonella* has a thin peptidoglycan cell wall and produces exotoxins

(b) A scientist studied the growth of *Salmonella*.

- (i) *Salmonella* was isolated from a mixed culture of bacteria, using streak plating onto selective media.

Explain why this is a suitable method for isolating the *Salmonella*.

(4)

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- (ii) The scientist made a broth culture of *Salmonella* at a concentration of 5×10^3 cells per cm^3 .

Ten hours later the concentration of *Salmonella* was 4×10^6 per cm^3 .

Calculate the exponential growth rate constant (k) for this culture of *Salmonella* using the formula

(3)

$$k = \frac{\log_{10} N_t - \log_{10} N_0}{0.301 \times t}$$

Answer

- (iii) In this calculation, the scientist did not allow for the time that the *Salmonella* spent in the lag phase.

Explain the effect that this will have on the calculated value for the growth rate constant.

(3)

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5 (a) Bacteria are prokaryotes.

- (i) Give **two** differences between the structures of a prokaryotic cell and a eukaryotic cell.

(2)

- (ii) Gram staining is often used to help identify bacteria.

A sample of bacteria from an infected person was tested by using Gram staining.

The bacteria stained red.

Explain why the bacteria stained red **and** why this information is useful for treating the infected person.

(3)



(b) (i) Describe the method used to isolate individual species from a mixed culture of bacteria in nutrient broth.

(4)

(ii) Explain **three** precautions that would be taken to reduce the growth of pathogenic bacteria.

(3)

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8 Skin flora include bacteria that live on the skin.

Different parts of the body have different types of bacteria present.

Skin flora are beneficial as they inhibit the growth of pathogenic bacteria on the skin.

Skin flora compete for nutrients and space or secrete toxic chemicals.

(a) The following are types of bacteria found in the female genital tract:

- *Escherichia coli*
- *Klebsiella* species
- *Lactobacillus* species
- *Staphylococcus* species.

(i) Describe how these types of bacteria present in the female genital tract could be identified.

(4)

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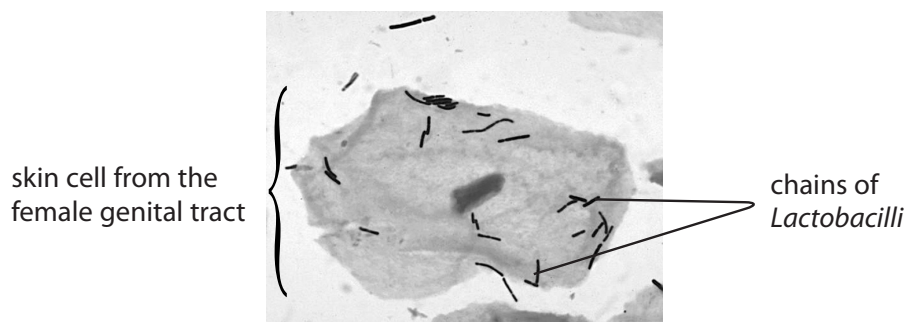
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(ii) The photograph shows *Lactobacilli* on a skin cell from the female genital tract.



Source: © Janice Carr Content Providers (s): CDC/Dr. Mike Miller

Lactobacilli metabolise glycogen into lactic acid.

Explain how *Lactobacilli* inhibit the growth of pathogenic bacteria in the female genital tract.

(3)

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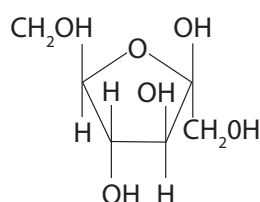
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(b) Sperm cells are released into the female genital tract in seminal fluid.

Seminal fluid contains fructose instead of glucose.

The diagram shows the structure of fructose.



(i) Compare and contrast the structure of fructose with the structure of glucose.

(3)

(ii) Explain the advantages of the presence of fructose in seminal fluid.

(3)

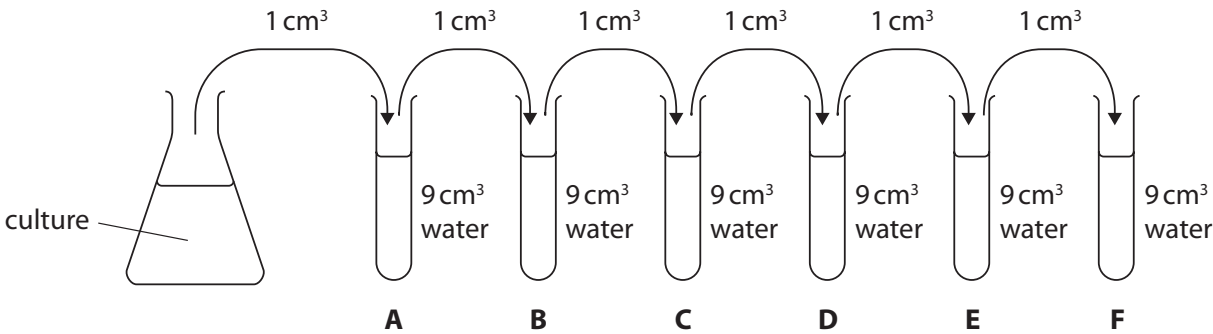


11 The growth of bacterial populations can be studied if they are grown in liquid culture.

(a) One type of bacteria is grown in nutrient broth under aseptic conditions.

The number of bacteria in the culture at a particular time can be determined using serial dilution and plating.

The diagram shows the dilution series used.



One sample of 0.5 cm³ is taken from each tube (A to F). Each sample is spread onto a separate agar plate using aseptic technique.

The plates are incubated at 25 °C for 48 hours and the number of colonies on each plate is counted.

Each colony represents a single bacterium in the original culture.

The table shows the results obtained.

Tube	A	B	C	D	E	F
Number of colonies on agar plate	*	*	126	13	1	0
Serial dilution factor	1 in 10					

* = too many colonies to count

(i) Calculate the number of bacteria per cm^3 in the original culture.

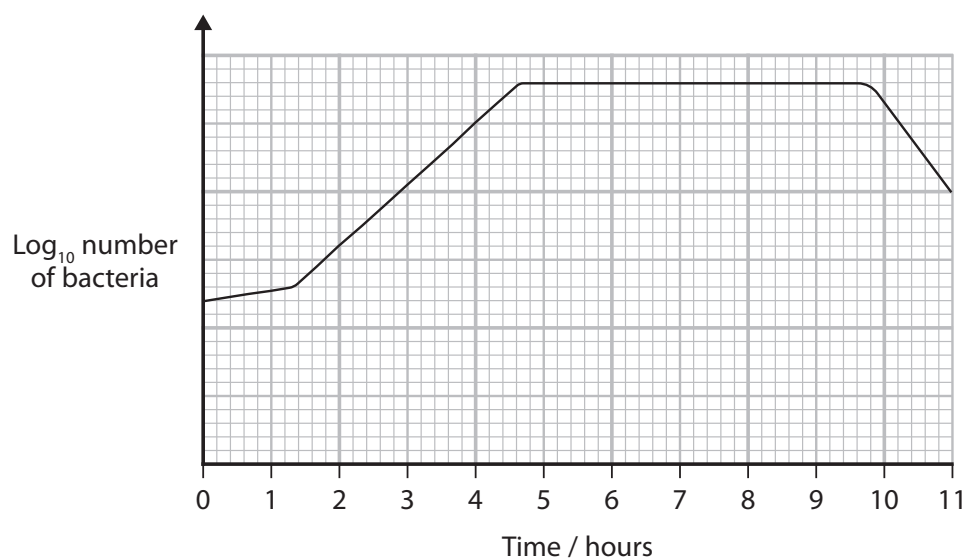
Give your answer in **standard form**.

(2)

Answer per cm^3



- (ii) The graph shows the population of bacteria in a culture, as determined using this method.



Explain the shape of this graph.

(4)

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- (iii) Between 1.3 hours and 4.7 hours the number of bacteria is rising very rapidly.

The number of bacteria can be calculated at any time in this period using the exponential growth rate constant, k .

The number of bacteria per cm^3 at the start of this period was 400 and the number 3.4 hours later was 102 400.

Calculate the value of k when the culture has been growing exponentially for 3.4 hours.

Give your answer to **two decimal places**.

Use the formula:

$$k = \frac{\log_{10} N_t - \log_{10} N_0}{0.301 \times t}$$

where N_t = the number of organisms at time t

N_0 = the number of organisms at time 0

k = the exponential growth rate constant

t = the time the culture has been growing

(2)

Answer

- (iv) Calculate the mean generation time, g (time for the population of bacteria to double, in minutes).

Use your value for k and the formula $k = \frac{60}{g}$

(1)

Answer minutes



- (b) An alternative method to dilution plating is to use a colorimeter to measure the turbidity of a culture.

Turbidity is an indicator of the growth of the bacterial population.

Assess the advantages of each of these methods to measure the growth of a bacterial population.

(4)



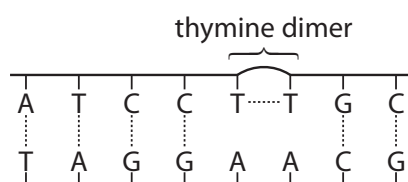
- 6 Ultraviolet (UV) radiation damages DNA and is used in microbiology to produce aseptic conditions.

The UV radiation changes the bonding found in DNA.

This change in bonding creates thymine dimers in which covalent bonds form between adjacent thymine nucleotides.

Thymine dimers bend the DNA backbone. This prevents replication of DNA.

The diagram shows the change in bonding caused by UV radiation.



- (a) Name the bonds that are lost when thymine dimers are formed.

(1)

- (b) Explain why preventing the replication of DNA produces aseptic conditions.

(2)



- (c) Aseptic conditions are used when growing bacteria in laboratories.

Justify two methods, other than UV radiation, for ensuring aseptic conditions.

(2)

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- (d) The effectiveness of UV radiation was investigated, using three species of pathogenic bacteria.

The table provides information about the bacteria used in this investigation.

Bacteria	Gram staining	Infected part of body
<i>P. aeruginosa</i>	negative	blood
<i>S. aureus</i>	positive	lung
<i>E. coli</i>	negative	intestine

- (i) Compare and contrast the structure of the wall of Gram positive bacteria and Gram negative bacteria.

(3)

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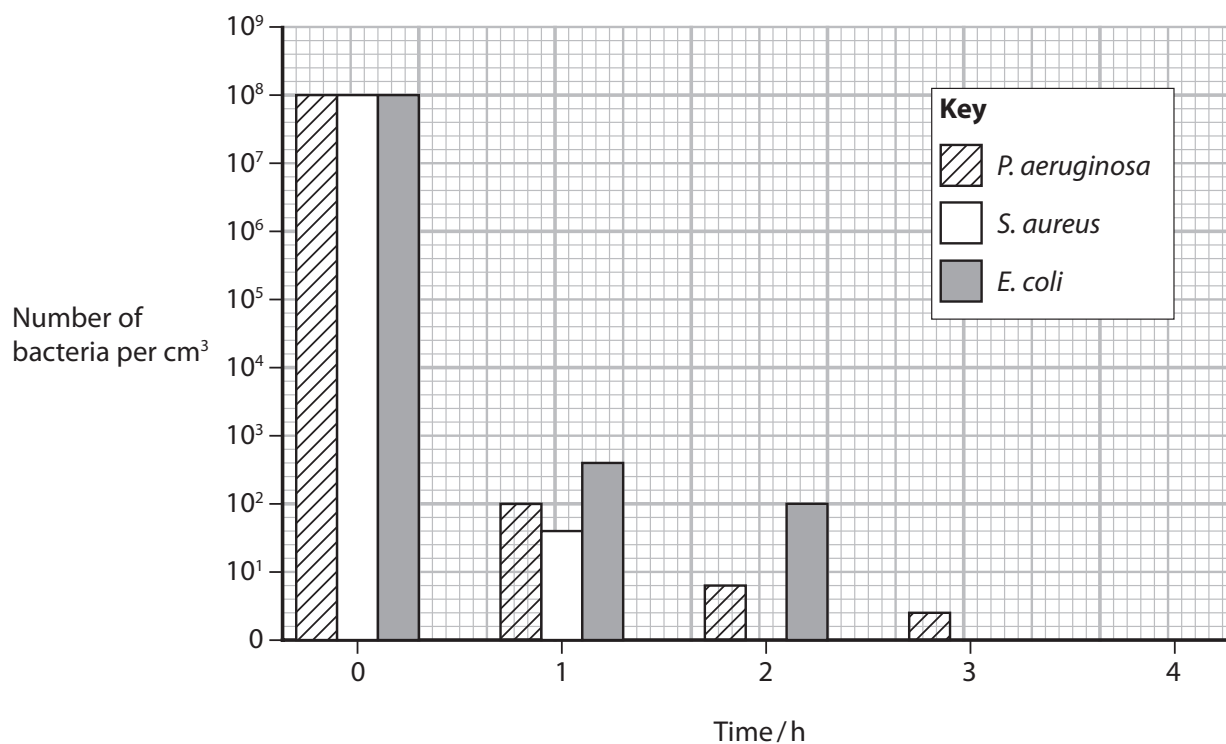
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- (ii) In this investigation, living bacteria of each species were exposed to UV radiation for four hours.

The numbers of living bacteria were counted each hour during the four-hour period.

The graph shows the results of this investigation.



Calculate the percentage change in numbers of living *E. coli* after two hours of exposure to UV radiation.

(2)

Answer %

(iii) A student concluded from this investigation that if food is exposed to UV radiation, it would remove all risk of food poisoning.

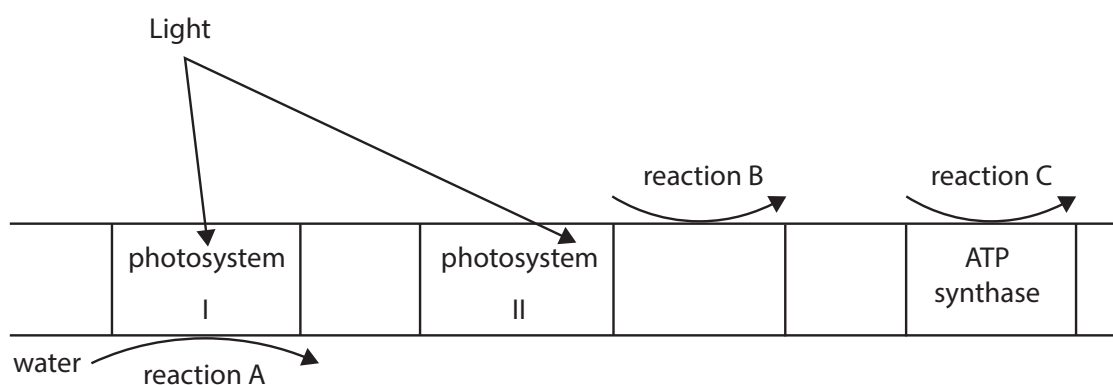
Criticise the validity of this conclusion.

(4)



6 *Chlorella* are single-celled photosynthetic algae.

(a) The diagram shows part of a membrane in a chloroplast from *Chlorella*.



(i) Which membrane is shown in this diagram?

(1)

- ☒ A crista
- ☒ B inner
- ☒ C outer
- ☒ D thylakoid

(ii) Name reaction A.

(1)

(iii) What occurs in reaction B?

(1)

- ☒ A reduced NADP is broken down by gaining an electron
- ☒ B reduced NADP is broken down by losing an electron
- ☒ C reduced NADP is produced by gaining an electron
- ☒ D reduced NADP is produced by losing an electron

(iv) Write the equation for reaction C.

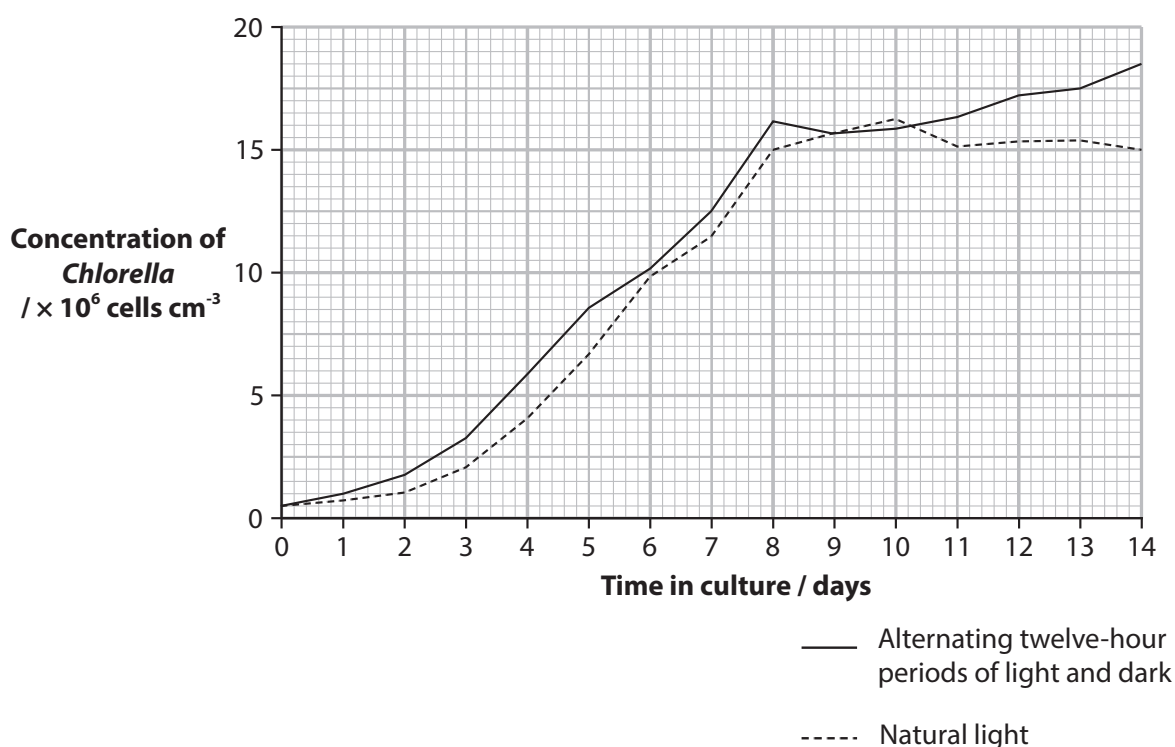
(1)

- (b) Scientists are developing solar cells that contain photosynthetic pigments derived from *Chlorella*.

Solar cells absorb light and generate electricity.

The scientists cultured *Chlorella* under two different lighting conditions.

The graph shows the growth of *Chlorella* exposed to either natural light or to alternating twelve-hour periods of light and dark.



- (i) The mean growth rate for *Chlorella* grown in natural light during the fourteen-day period was 1.04×10^6 cells per day.

Calculate how many times faster *Chlorella* grew in alternating periods of light and dark.

Give your answer to **two significant figures**.

(2)

Answer

(ii) The cultures were observed for a further four days.

The table shows the observations.

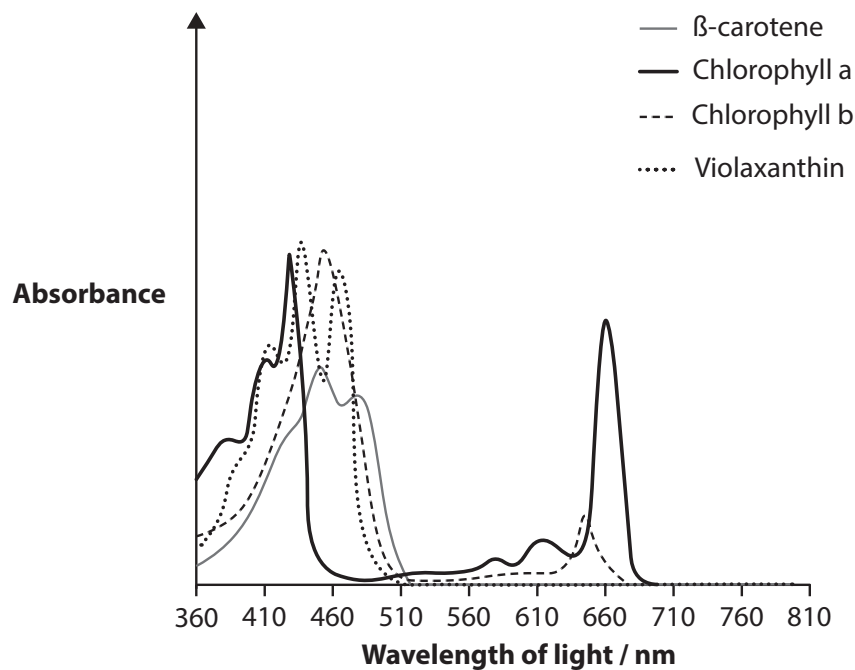
Time in culture / days	Observation	
	<i>Chlorella</i> grown in alternating periods of light and dark	<i>Chlorella</i> grown in natural light
17	Dark green cells	Light green cells
	The number of cells had not increased since the previous day	The number of cells had increased since the previous day
18	Cells had entered the death phase	Cells had not entered the death phase

Explain these observations.

(5)

- (iii) The scientists chose to use *Chlorella* as a source of photosynthetic pigments for solar cells.

The graph shows the absorption spectra of four photosynthetic pigments found in *Chlorella*.



Explain why *Chlorella* cells are a suitable source of photosynthetic pigments for use in a solar cell.

(3)

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- 11** Yeast, *Saccharomyces cerevisiae*, is a single-celled organism used in brewing and baking.

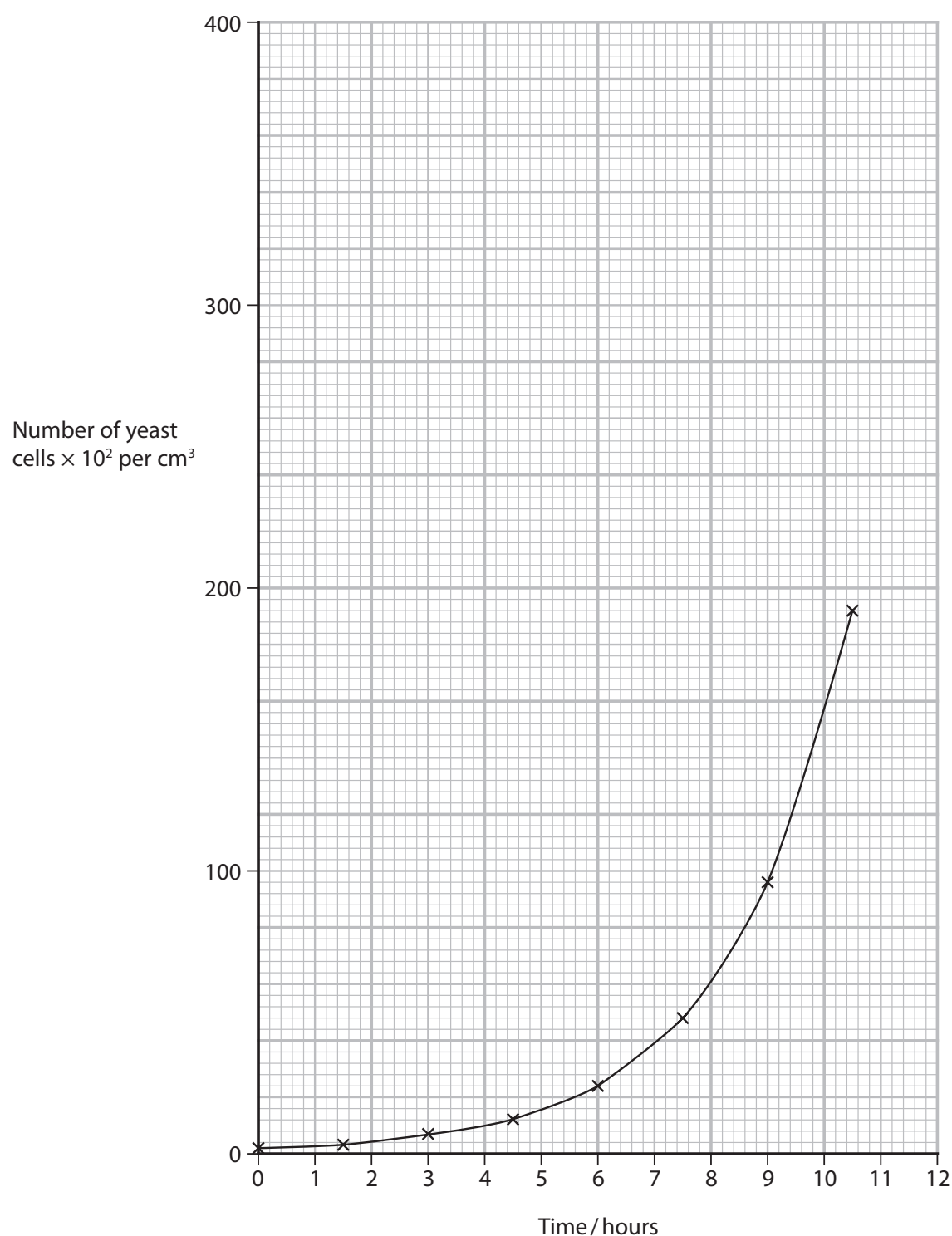
The photograph shows yeast cells seen using a light microscope.



(Source: © Kateryna Kon/Shutterstock)

A student counted the number of yeast cells, at 90-minute intervals, growing in a liquid culture at 30°C.

The graph shows the results.



- (a) (i) Calculate the percentage increase in the number of yeast cells from 2 hours to 6 hours.

(2)

Answer %

- (ii) Predict the number of cells per cm^3 of the culture at 12 hours.

Assume that the culture continues to grow at the same rate.

(1)

Answer $\times 10^2$ per cm^3

- (b) Describe two precautions that would prevent the yeast culture becoming contaminated with bacteria.

(2)

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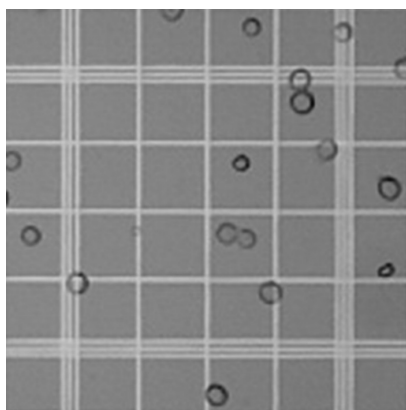


- (c) The student counted the yeast cells using a haemocytometer.

This is a slide with chambers containing a known volume of liquid. The yeast cells are counted when viewed using a light microscope.

Any yeast cells totally within the counting square should be counted, along with those which overlap the top or left-hand side of the square.

- (i) The volume of liquid in the counting square shown is 0.004 mm^3 .



(Source: © Joseph Elsbernd/Flickr)

Calculate the number of yeast cells per mm^3 .

Give your answer in standard form.

(2)

Answer per mm^3

- (ii) Identify two causes of inaccuracy in this method of counting cells.

(2)

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(d) The table shows the number of cells counted using a haemocytometer.

Time / hours	Number of cells						
	1	2	3	4	5	Mean	Standard deviation (SD)
0.0	1	2	2	1	2	1.6	0.5
1.5	2	3	3	3	2	2.6	0.5
3.0	4	9	9	3	7	6.4	
4.5	13	10	12	9	16	12.0	2.7
6.0	43	31	18	14	15	24.2	12.5

(i) The student calculated the standard deviations using the following formula.

$$SD = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$

Calculate the standard deviation for the sample at 3 hours.

(3)

Answer



(ii) The student concluded that the yeast population doubles every 90 minutes.

Comment on the validity of this conclusion.

(3)



SUB-TOPIC 6(b)

PATHOGENS AND INFECTIOUS DISEASE

9 questions in this sub-topic · 85 marks · lowest tariff first



1 The pathogenic effects of bacteria can be due to the toxins they release.

(a) Endotoxins are released by Gram negative bacteria.

(i) Name **one** type of Gram negative bacteria that releases endotoxins.

(1)

(ii) Give **one** difference between the structure of Gram negative bacteria and Gram positive bacteria.

(1)

(b) Endotoxins are usually less toxic than exotoxins.

(i) The LD_{50} value is the mass of the chemical per kg of body mass that would kill half the number of rodent animals.

The LD_{50} value can be used to indicate how toxic a chemical is.

One endotoxin has an LD_{50} value of 11 ng kg^{-1} .

The mean body mass of a group of rodents is 28 g.

Calculate the mass of endotoxin given to each rodent that would kill half of the rodents in this group.

(1)

Answer ng

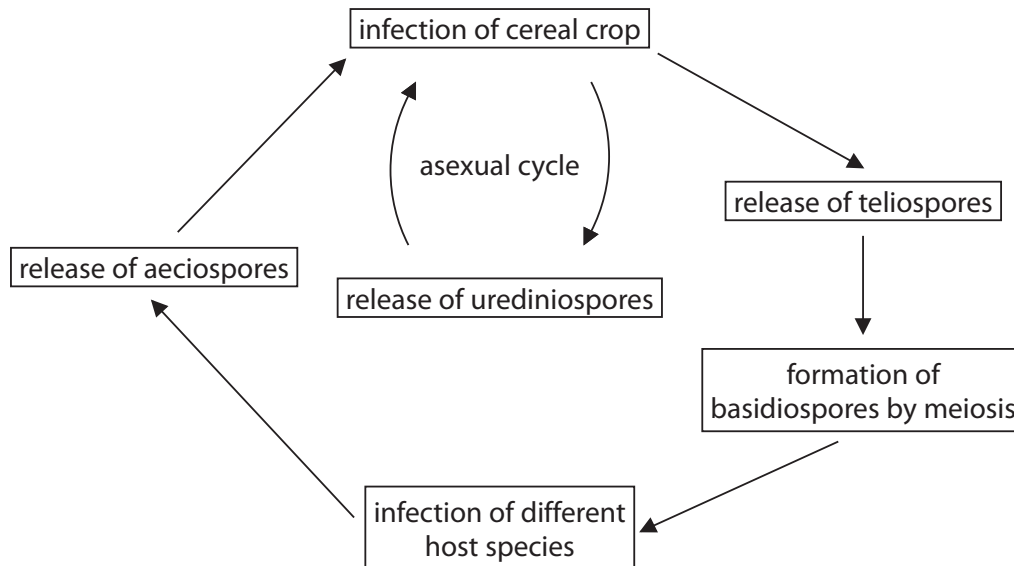
(ii) State **two** differences, other than toxicity, between endotoxins and exotoxins.

(2)



- 3 The stem rust fungus is responsible for destroying cereal crops and reducing grain yield.

The diagram shows some stages in the life cycle of the stem rust fungus.



- (a) Which genus does the stem rust fungus belong to?

(1)

- ☐ A *Plasmodium*
- ☐ B *Puccinia*
- ☐ C *Salmonella*
- ☐ D *Staphylococcus*

(b) Explain how stem rust fungus results in a reduction in grain yield.

(3)

(c) Cereal crops have been genetically modified (GM) to produce plants that are resistant to stem rust fungus.

Analyse the diagram to deduce why the formation of basidiospores and urediniospores can produce a stem rust fungus to which these GM plants are no longer resistant.

(3)



3 Malaria is a serious and sometimes fatal disease.

Scientists are constantly looking for new ways of controlling this disease.

- (a) Which row of the table shows the name of the pathogen that causes malaria, and its classification group?

(1)

	Name of pathogen	Classification group
☐ A	<i>Plasmodium</i>	genus
☐ B	<i>Plasmodium</i>	species
☐ C	<i>Puccinia</i>	genus
☐ D	<i>Puccinia</i>	species

- (b) One group of scientists has genetically modified a fungus to produce a spider toxin that kills mosquitoes.

Describe how a fungus could be genetically modified to produce spider toxin.

(3)

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- (c) Another group of scientists has discovered a type of fungus that completely protects mosquitoes from infection by the pathogen that causes malaria.

This fungus does not kill the mosquitoes.

Explain why this approach is less controversial than the approach used by the scientists who are developing the genetically-modified fungus.

(3)

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4 Influenza is an infectious disease caused by a virus.

(a) The influenza virus is an RNA virus and has an envelope.

Which pair of viruses also have RNA and an envelope?

(1)

- ☐ A Ebola and human immunodeficiency virus
- ☐ B Ebola and tobacco mosaic virus
- ☐ C human immunodeficiency virus and λ phage
- ☐ D tobacco mosaic virus and λ phage

(b) Which of the following is the predominant method of transmission of the influenza virus?

(1)

- ☐ A contaminated surfaces
- ☐ B contaminated food
- ☐ C respiratory droplets
- ☐ D insect vectors

(c) Symptoms of influenza appear some time after a person is infected with the virus.

Explain why there is a time delay between infection and the symptoms appearing.

(3)

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(d) In some countries, people take antibiotics without a prescription.

In a survey, 77% of people who had taken antibiotics had taken them without a prescription.

Some of the people who took antibiotics without a prescription had influenza.

- (i) Calculate the ratio of the number of people who took antibiotics without a prescription to the number of people who took antibiotics with a prescription.

Give your answer to two decimal places.

(1)

Answer

- (ii) Explain why antibiotics should not be taken by people with viral infections.

(2)

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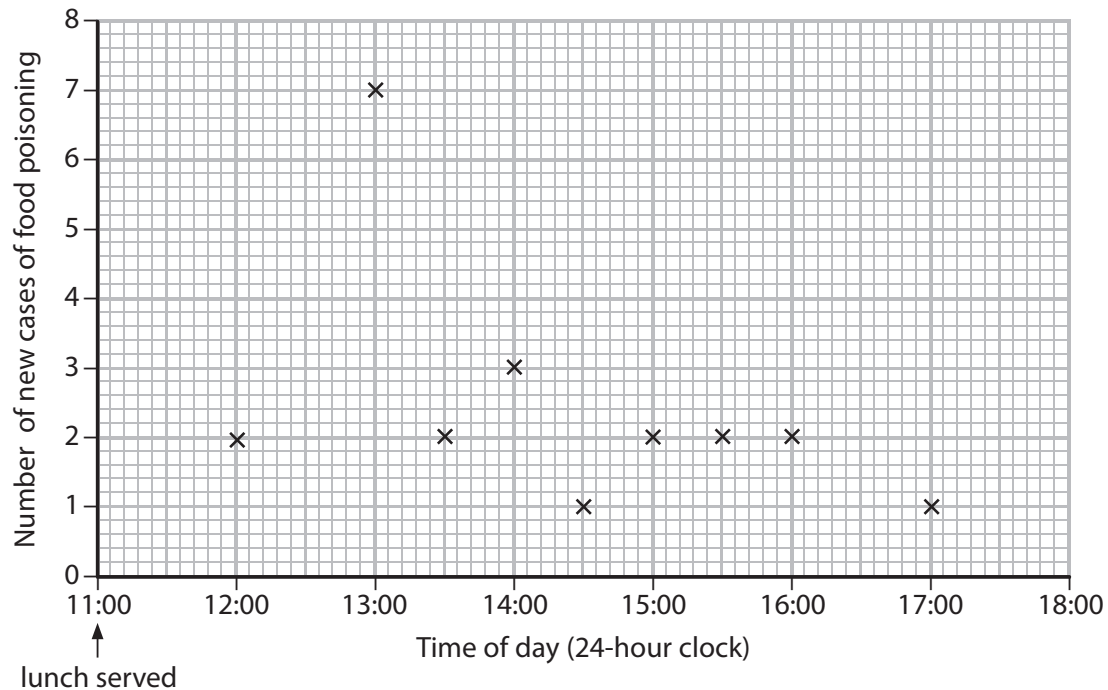
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3 Food poisoning can be caused by food that is contaminated with pathogenic microorganisms.

(a) A number of different bacteria can cause food poisoning.

The graph shows the number of new cases of food poisoning after a lunch party.



(i) Explain why it is likely that this food poisoning resulted from food contaminated with *Staphylococcus* rather than with *Salmonella*.

(3)

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- (ii) Describe the techniques microbiologists could use to confirm that this food poisoning was caused by *Staphylococcus*.

(4)

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- (b) A number of different viruses can cause food poisoning.

One virus that can cause food poisoning is the Norovirus.

Noroviruses are RNA viruses.

- (i) The following four statements are features of viruses:

1. have envelopes
2. contain reverse transcriptase
3. surrounded by a protein coat
4. have a helical structure

Which of the following is correct for all RNA viruses?

(1)

- ☐ **A** statement 1, statement 2 and statement 3
- ☐ **B** statement 2 only
- ☐ **C** statement 3 only
- ☐ **D** statement 1 and statement 4

(ii) Which of the following groups of viruses are also RNA viruses?

(1)

- ☐ **A** Ebola virus, human immunodeficiency virus and tobacco mosaic virus
- ☐ **B** Ebola virus, λ phage and tobacco mosaic virus
- ☐ **C** Human immunodeficiency virus, λ phage and tobacco mosaic virus
- ☐ **D** λ phage and tobacco mosaic virus

(Total for Question 3 = 9 marks)



3 Mosquitoes transmit a number of diseases, including malaria.

The photograph shows a mosquito, *Anopheles gambiae*.

This mosquito transmits malaria.



Source: © Sinclair Stammers / Science photo library

(a) (i) State the genus of this mosquito.

(1)

(ii) Mosquitoes belong to the class Insecta.

Some of the insects in this class are subdivided into a group called Diptera.

What is the name of the classification group that includes Diptera?

(1)

- ☐ A Family
- ☐ B Genus
- ☐ C Order
- ☐ D Phylum

(iii) Which of the following organisms causes the symptoms of malaria?

(1)

- ☐ A *Anopheles gambiae*
- ☐ B *Plasmodium falciparum*
- ☐ C *Puccinia graminis*
- ☐ D *Salmonella enterica*

(b) From 2010 to 2015 there was a 29% decrease in the number of deaths from malaria. This was due to prevention and control measures.

(i) Explain **one** implication of a named method of controlling malaria.

(2)

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(ii) In 2015, the number of deaths from malaria was 429 000.

Calculate the number of deaths from malaria in 2010.

(2)

Answer

(c) In 2015, the number of cases of malaria was 211 million. This increased to 216 million cases in 2016.

Give the change in the number of cases of malaria in standard form.

(1)

Answer



(d) Scientists are researching new methods of controlling malaria.

One group used a procedure called gene drive.

This procedure resulted in female mosquitoes that could not bite or could not lay eggs.

One of the scientists said:

'It will still be at least 5 to 10 years before we consider testing any mosquitoes with gene drive, but now we have some encouraging proof that we're on the right path.'

Explain why this group are sharing the results of their research.

(2)

5 Septicaemia is a life-threatening condition that can arise from bacterial infection.

- (a) In one year, 245 000 people were diagnosed with septicaemia and 49 735 of these people died as a result.

Which percentage of people **survived** septicaemia in this year?

(1)

- ☐ A 20.3%
- ☐ B 25.5%
- ☐ C 39.3%
- ☐ D 79.7%

- (b) Two types of bacteria that cause septicaemia are *Escherichia coli* (*E. coli*) and *Staphylococcus aureus* (*S. aureus*).

E. coli is Gram negative and *S. aureus* is Gram positive.

- (i) Which of the following statements about the cell walls of these bacteria are correct?

(1)

1. Both bacteria have peptidoglycan (murein) in their cell walls.
2. *S. aureus* has an outer membrane (lipopolysaccharide layer).
3. The cell wall of *E. coli* is thinner than that of *S. aureus*.

- ☐ A 2 only
- ☐ B 3 only
- ☐ C 1 and 2 only
- ☐ D 1 and 3 only

(ii) Both *E. coli* and *S. aureus* produce toxins.

E. coli produces the same type of toxin as *Salmonella* bacteria.

Which of the following statements about the toxins produced by these bacteria are correct?

(1)

1. *E. coli* produces endotoxins.
2. The toxins produced by *S. aureus* are released only once the bacteria die.
3. The toxins produced by *S. aureus* are components of their cell wall.

- ☐ **A** 1 only
- ☐ **B** 2 only
- ☐ **C** 1 and 2 only
- ☐ **D** 1, 2 and 3

(c) Vaccines against bacteria are not always effective. The antigens they contain stimulate only a weak immune response.

Which of the following types of immune response is stimulated by a vaccine?

(1)

- ☐ **A** artificial active
- ☐ **B** artificial passive
- ☐ **C** natural active
- ☐ **D** natural passive

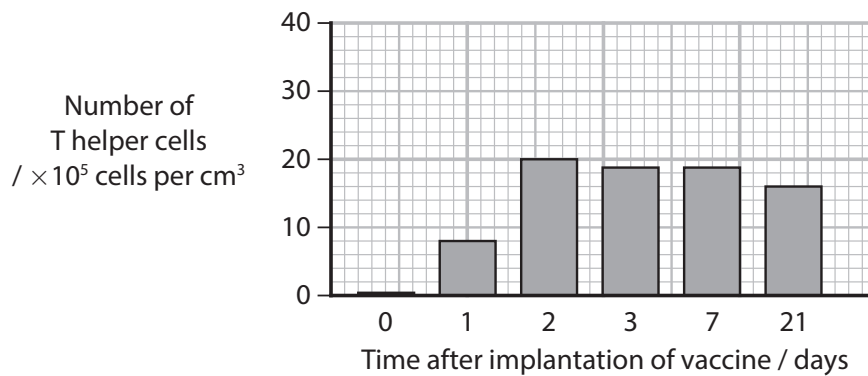
- (d) There are currently no vaccines for either *E. coli* or *S. aureus*.

Scientists are developing vaccines against *E. coli* and *S. aureus* which can be implanted under the skin.

The bacterial antigens are held in a mesh that contains chemicals to attract tissue macrophages.

The effect of implantation of these vaccines on the immune response in mice was investigated.

- (i) The graph shows the number of T helper cells in the lymph nodes that drain the part of the body where the vaccine was implanted.



Explain the results shown in the graph.

(3)

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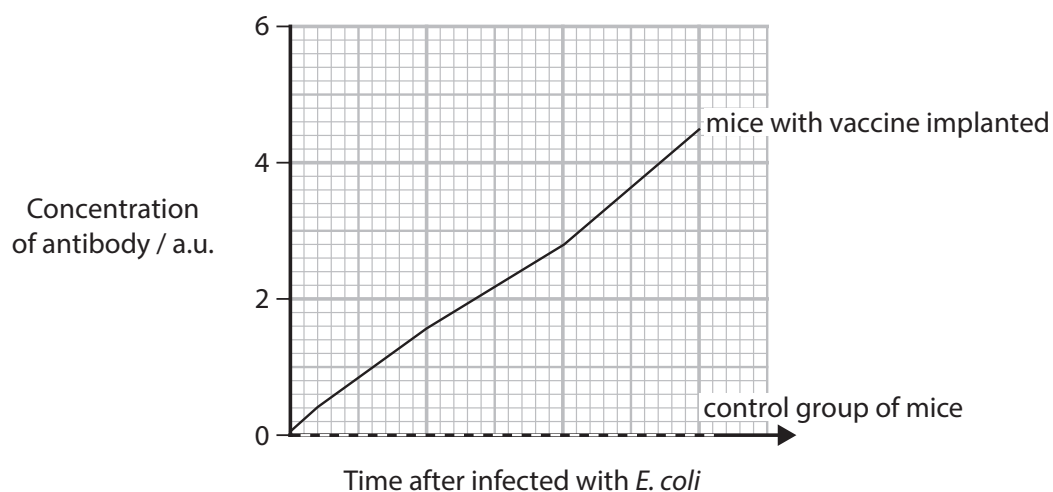
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- (ii) In part of this investigation, mice had the vaccine implanted 35 days before being infected with *E. coli*.

A control group that had not received the vaccine was also infected with *E. coli*.

The levels of antibody in the blood of both groups of mice were determined.

The graph shows these results.



Explain the results shown in the graph.

(3)

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7 Diseases caused by viruses, such as Ebola, can be difficult to treat.

(a) Which of the following statements are correct for Ebola?

1. It contains DNA
2. It has an envelope
3. It is a retrovirus

(1)

- ☐ **A** 1 only
- ☐ **B** 2 only
- ☐ **C** 1 and 3 only
- ☐ **D** 2 and 3 only

(b) Explain why diseases caused by viruses are difficult to treat.

(2)

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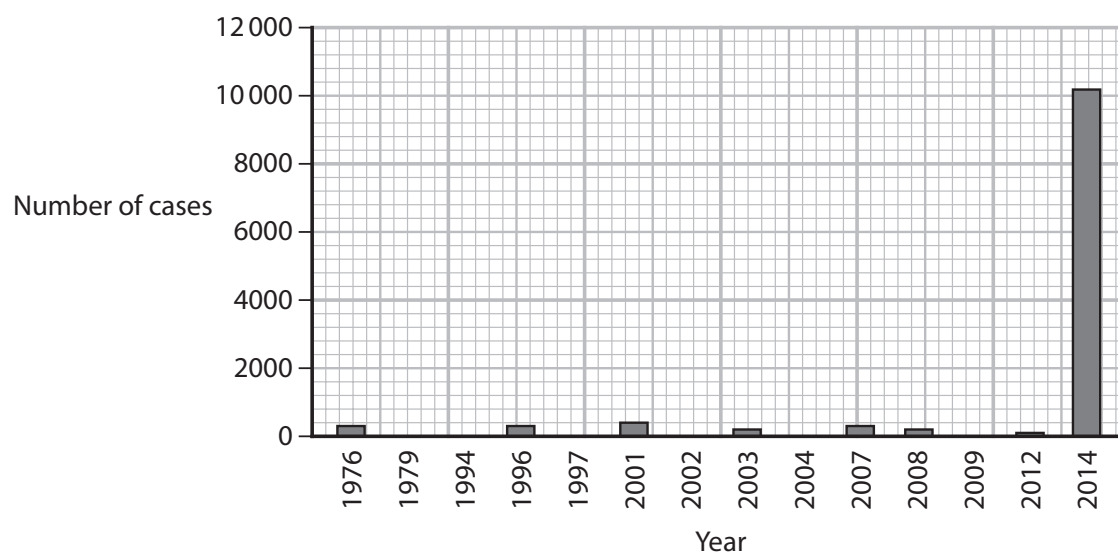
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- (c) The graph shows the number of cases of Ebola in each outbreak from 1976 to 2014.



- (i) State **two** conclusions that can be made about the outbreaks of Ebola in this time period.

(2)

1

2

(ii) Give **two** reasons why the figures presented in this graph are likely to be an underestimate.

(2)

1

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2

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(iii) In October 2014, 10 141 cases and 4 922 deaths were reported.

Calculate the ratio of cases to deaths.

Give your answer in whole numbers.

(1)

Answer

*(d) The Ebola virus can spread between animals and humans and between humans.

The virus is present in bodily fluids of both infected animals and humans.

It can be passed on by contact with contaminated fluids, through open wounds, or by eating contaminated meat and fruits.

The spread of the disease is also affected by:

- changes in climate
- changes in land-use
- the economy of the country
- the health of the people.

A model has been developed to predict when and where outbreaks of Ebola could occur.

This model has shown that some countries in Africa are at risk of an outbreak of Ebola even though there have not been any known cases of Ebola there before.



Analyse the information to discuss the measures that could be used to reduce the risk of an Ebola outbreak in these countries.

(6)

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8 Some viruses cause infections in humans.

Antiviral drugs affect the virus without affecting the cells of the host.

(a) Explain why viruses are dependent on living cells.

(2)

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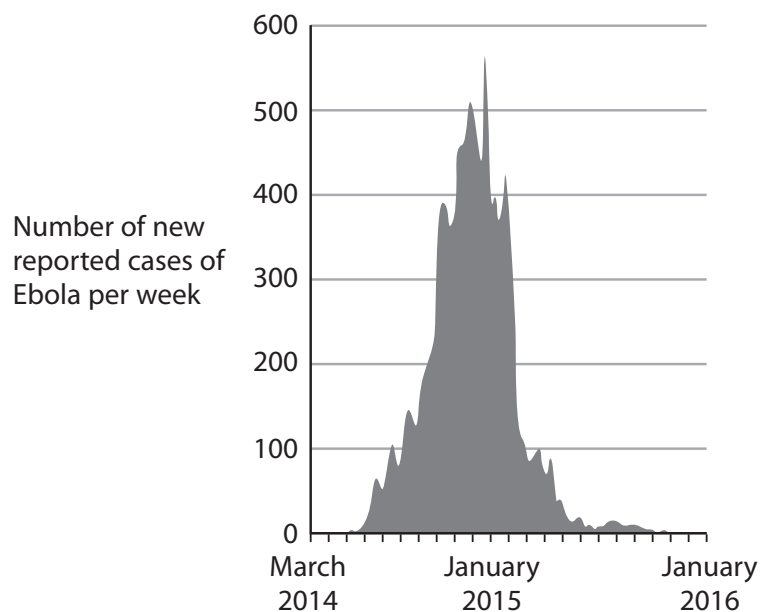
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(b) Ebola is a disease that has a high mortality rate.

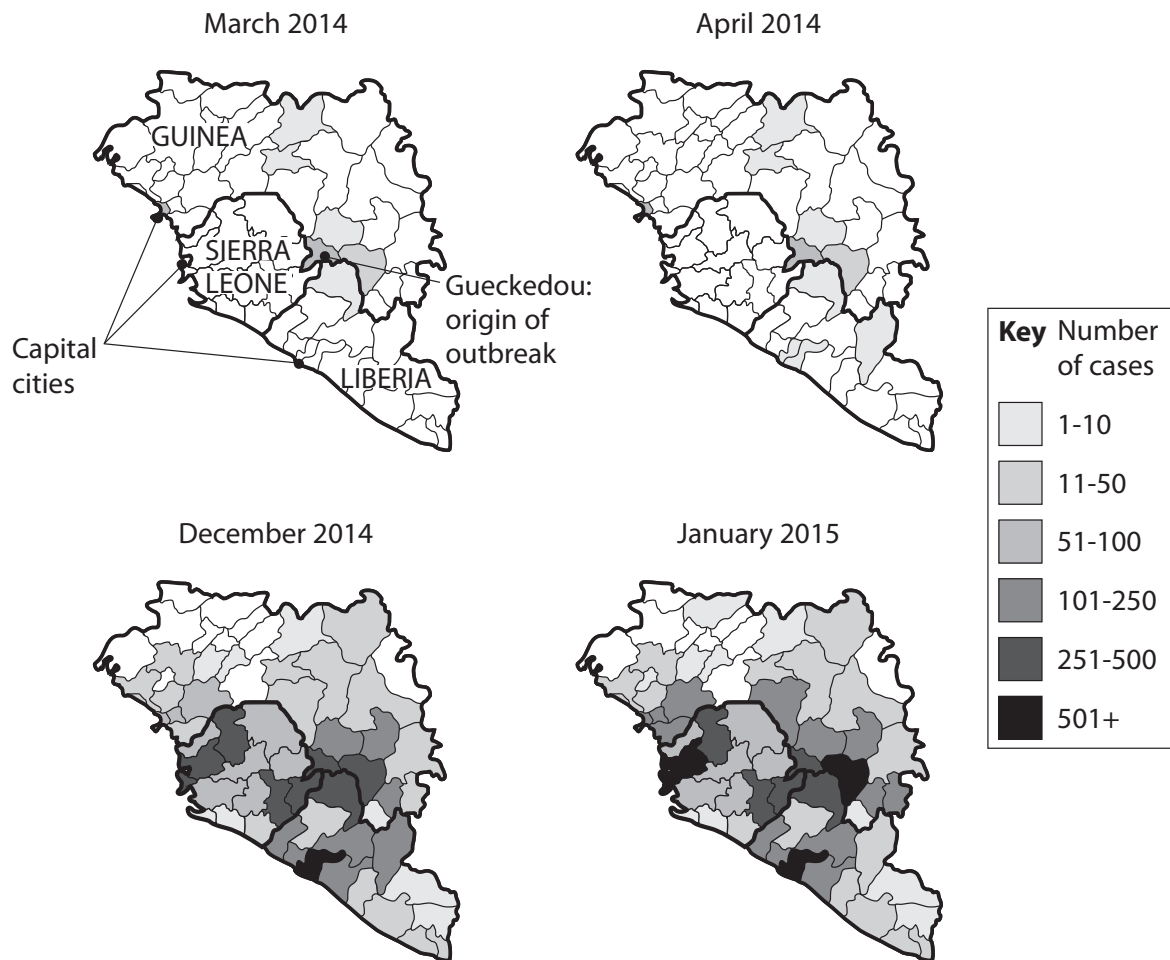
In 2014, there was an outbreak of Ebola in West Africa resulting in the deaths of over 11 000 people.

The graph shows the number of reported cases in Sierra Leone from March 2014 to January 2016.



The maps show the number of reported cases in districts of Sierra Leone, Guinea and Liberia in four months recorded during the outbreak.

The capital cities of these three countries are also shown.



*(i) Analyse the information in the graph and maps to comment on the spread of Ebola in West Africa.

(6)

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(ii) Describe the methods used to prevent the spread of Ebola.

(3)

(c) During this outbreak of Ebola, no vaccine had been developed.

The World Health Organisation recommended that untested antiviral drugs could be used to treat patients, due to the scale of the outbreak.

Evaluate the ethical implications of using an untested drug during this outbreak.

(4)



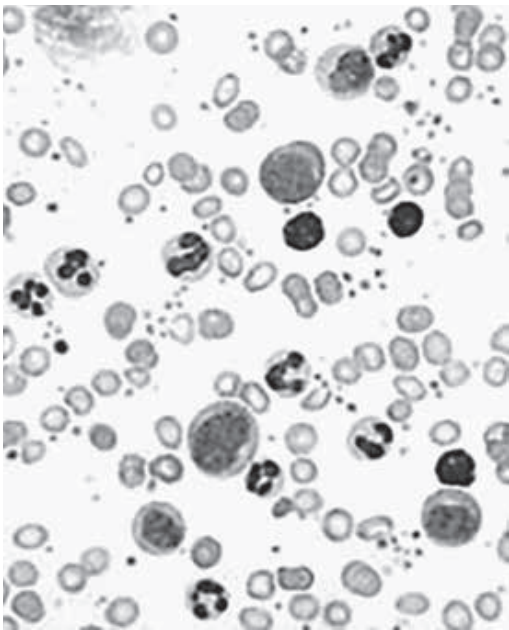
SUB-TOPIC 6(c)

THE IMMUNE RESPONSE AND VACCINATION

12 questions in this sub-topic · 136 marks · lowest tariff first



1 (a) The photograph shows a blood smear.



Which row of the table gives the correct number of each type of white blood cell in this photograph?

(1)

	Number of lymphocytes	Number of monocytes	Number of neutrophils
☐ A	3	5	8
☐ B	3	8	5
☐ C	5	3	8
☐ D	8	5	3

(b) Which row of the table gives the correct role of each of the blood components?

(1)

	Erythrocytes	Leucocytes	Platelets
☐ A	defence	transport	defence
☐ B	defence	defence	transport
☐ C	transport	defence	defence
☐ D	transport	transport	defence

(c) Blood taken from a patient had an unusually high proportion of eosinophils.

Explain why this patient had an unusually high proportion of eosinophils.

(2)

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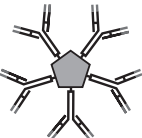
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- 5 The rubella virus stimulates the production of antibodies in humans but usually causes only mild infections.

However, infection of pregnant women can cause serious problems for the developing fetus.

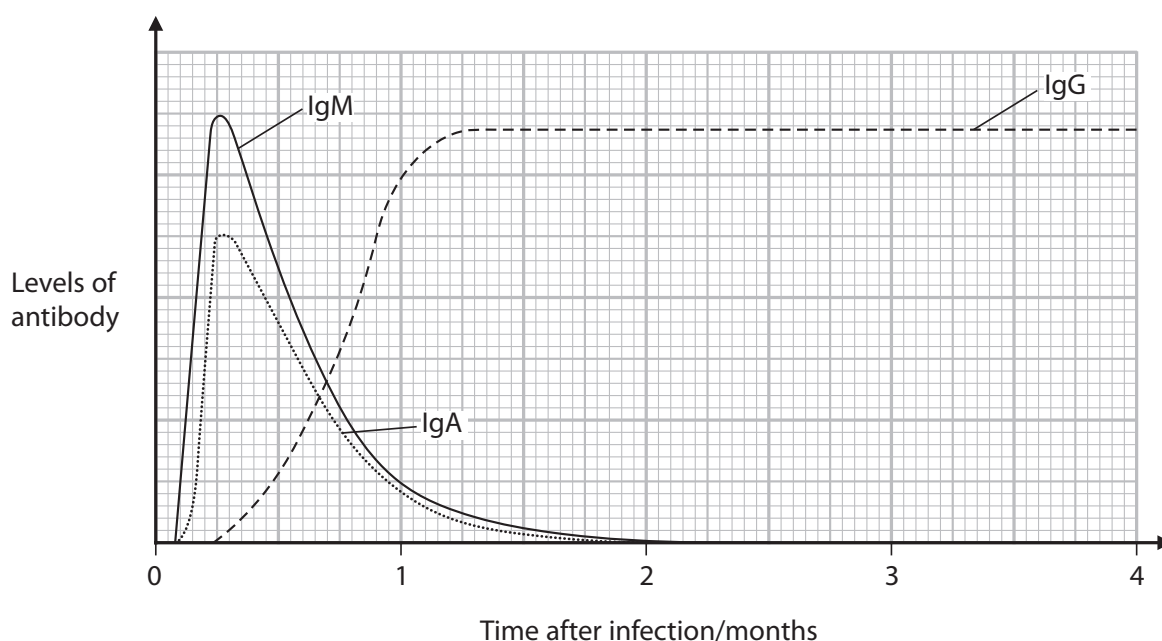
*(a) Antibodies can be divided into five classes.

The table gives some information about these classes of antibody.

Information	Class of antibody				
	IgM	IgA	IgG	IgD	IgE
Shape					
Number of antigen binding sites	10	4	2	2	2
Can cross the placenta	no	no	yes	no	no
Other details	secreted into the blood	secreted into mucus, tears, saliva, colostrum ¹	secreted into the blood	attached to the surface of B cells	involved in allergy and parasitic infections

¹ Colostrum is the first type of milk produced by the mother following birth.

The graph shows the levels of three of these classes of antibody produced in response to infection with the rubella virus.



Analyse the information in the table and the graph to assess the role of these five classes of antibody in the immune response to the rubella virus.

(6)

(b) Vaccination against rubella has helped to reduce the incidence of infection.

Explain the importance of vaccinating as many people as possible against rubella.

(2)

5 Some forms of infertility are due to the female producing antibodies to sperm cells.

Contraceptives are being developed that use these antibodies.

(a) Antibodies can be injected into a person to give immunity.

Which type of immunity develops from the injection of antibodies?

(1)

- ☐ A artificial active
- ☐ B artificial passive
- ☐ C natural active
- ☐ D natural passive

(b) In the development of these contraceptives, an agglutination assay was performed.

Antibodies were mixed with sperm cells and the time taken for 100% of the sperm cells to agglutinate was recorded.

Different concentrations of antibody were tested.

The number of sperm cells that escaped from the sperm cell agglutinates, at each concentration of antibody, was also recorded.

(i) Each test used $2\text{ }\mu\text{l}$ of a sperm cell suspension at a concentration of 3.0×10^6 cells per cm^3 .

$$1\text{ }\mu\text{l} = 10^{-6}\text{ dm}^3$$

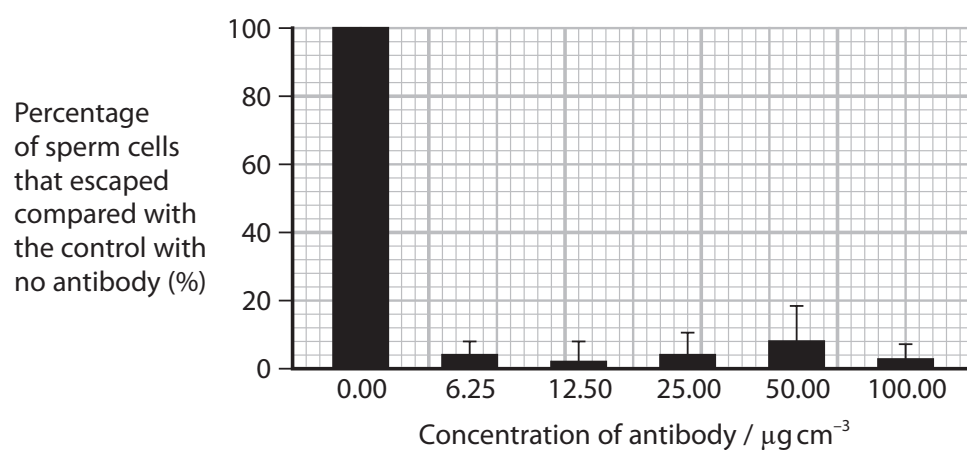
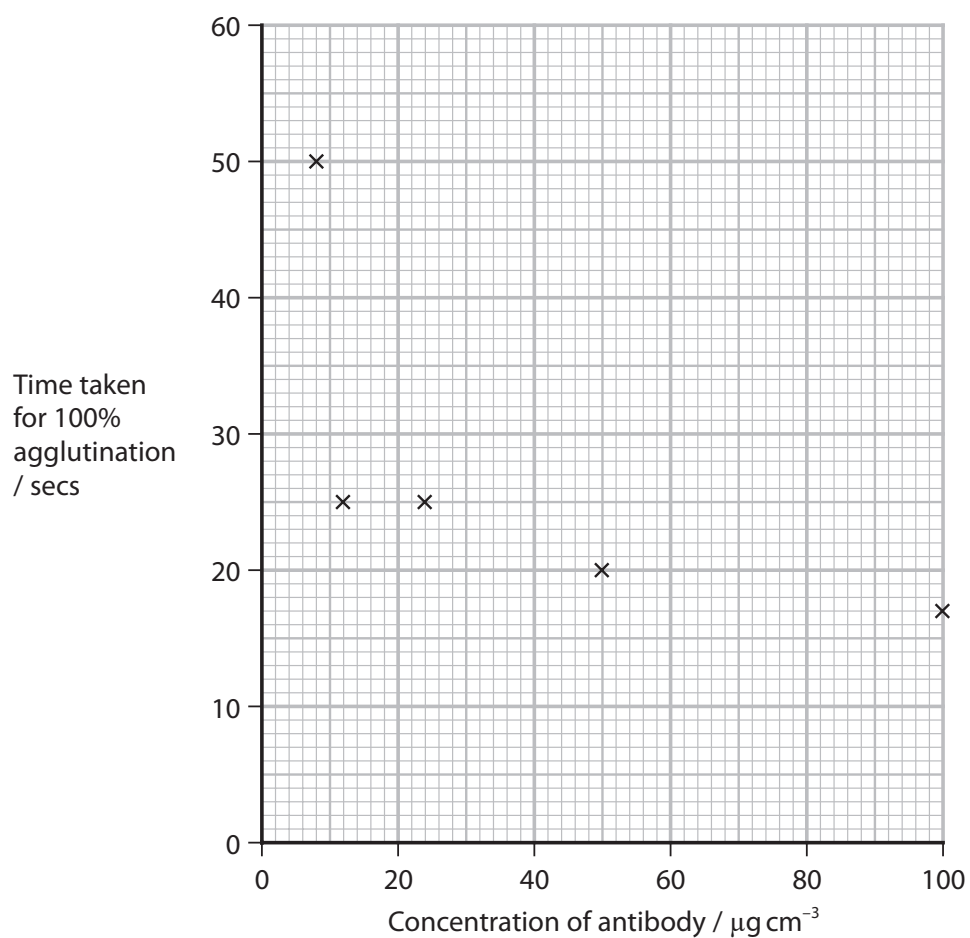
Calculate the number of sperm cells used in each test.

(1)

Answer



(ii) The graphs show the results of this assay.



Analyse the data to comment on these results.

(3)

- (iii) Observation of the sperm cells agglutinated by these antibodies showed that some were joined head to head, some head to flagellum and some flagellum to flagellum.

Explain these observations.

(3)

- (c) In the development of these contraceptives, the effect of the concentration of sperm cells on the time taken to agglutinate was also investigated.

Explain why agglutination could take longer at low and at high concentrations of sperm cells.

(2)



6 During the development of active immunity, macrophages present antigens to T helper cells.

(a) Describe how macrophages present antigens to T helper cells.

(2)

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(b) In an investigation into clonal selection, macrophages and T cells were isolated from two strains of guinea pig, strain 2 and strain 13.

The macrophages from each strain of guinea pig were exposed to an antigen and treated with mitomycin.

Mitomycin forms cross links between complementary strands of DNA.

These macrophages were then cultured with T cells from each of the strains of guinea pig for 72 hours.

Radioactive thymidine was included in the culture. This molecule will become incorporated into DNA during DNA replication instead of thymine.

The table shows the results of this investigation.

Source of macrophages	Level of radioactive thymidine incorporated into T cells / a.u.	
	T cells from strain 2 guinea pigs	T cells from strain 13 guinea pigs
strain 2	180	13
strain 13	17	59

(i) Explain why the macrophages were treated with mitomycin.

(3)

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(ii) Explain how radioactive thymidine becomes incorporated into the DNA.

(2)

(iii) Analyse the data to explain the results of this investigation.

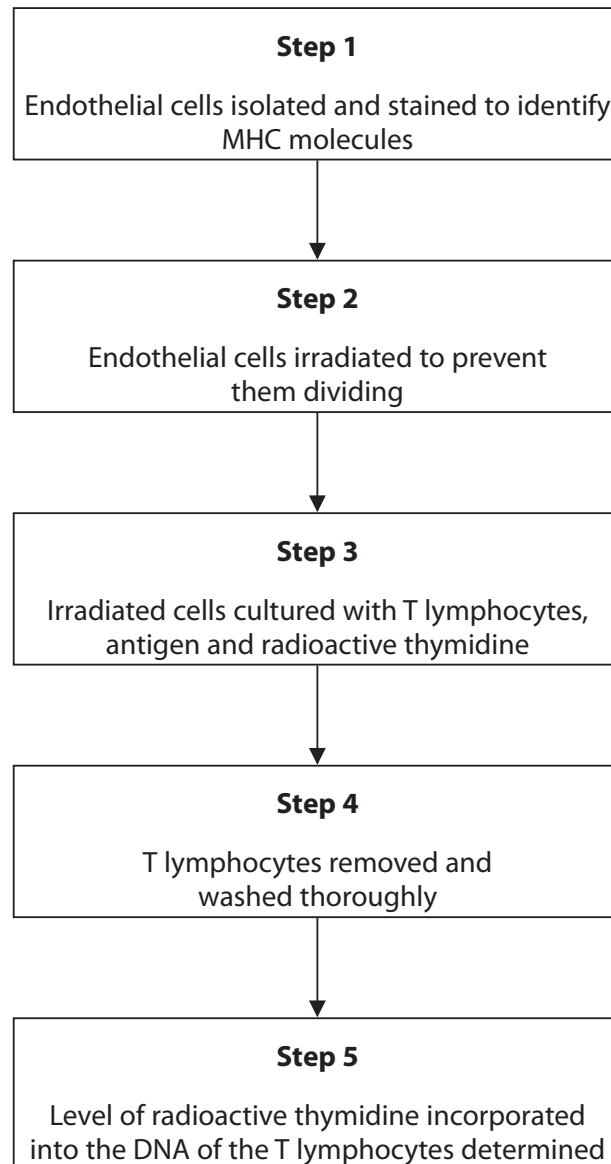
(4)



- 6 Cell division can be measured using radioactive thymidine. This molecule is used in the synthesis of new DNA molecules.

A scientist investigated the ability of endothelial cells to present antigens.

The flow chart shows some of the steps involved in this investigation.



- (a) Explain why the scientist looked for the presence of MHC molecules on the endothelial cells, in Step 1.

(2)

- (b) Irradiation prevents cells from dividing.

Explain why the endothelial cells were irradiated in Step 2, before they were cultured with T lymphocytes and antigen.

(2)

- (c) Explain why the T lymphocytes needed to be washed thoroughly in Step 4.

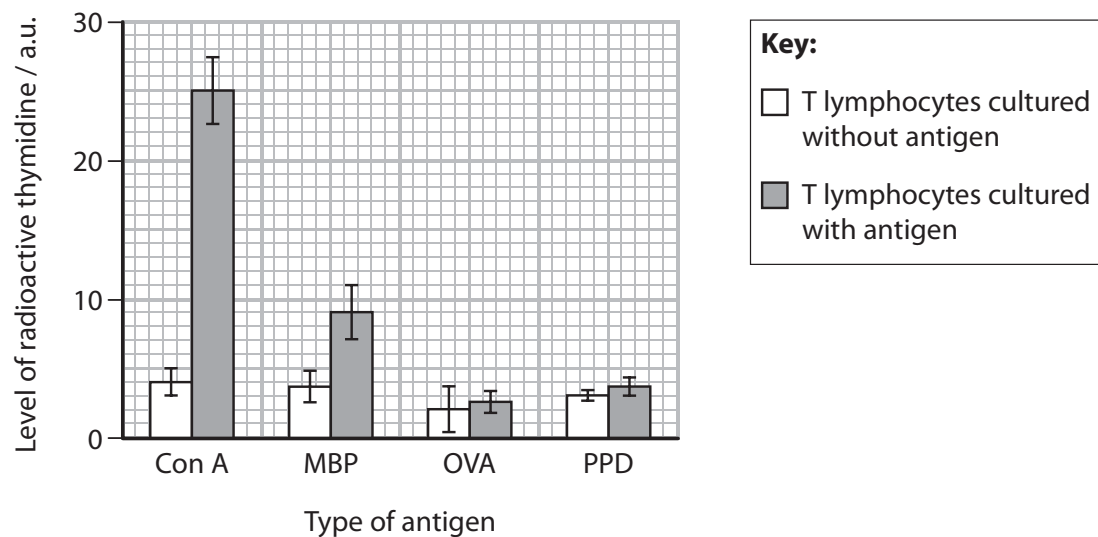
(2)

- (d) In this investigation, the ability of the endothelial cells to present four different types of antigen was assessed.

T lymphocytes were cultured with endothelial cells and antigen.

This was repeated using T lymphocytes cultured with endothelial cells and no antigen.

The graph shows the results of this investigation.



- (i) Explain why T lymphocytes were cultured with and without the antigen.

(2)

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- (ii) Analyse the data to explain the conclusions that can be drawn from this investigation.

(3)

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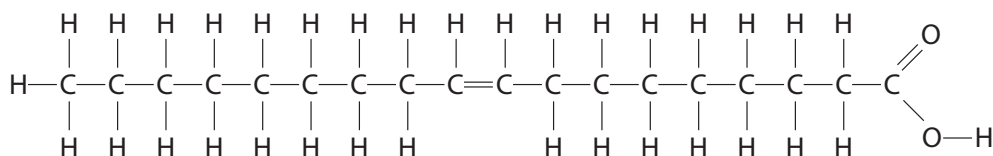
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- 7 Soya bean plants have been genetically modified (GM) to increase the concentration of certain organic molecules.

The diagram shows one of these molecules.



- (a) Explain what type of molecule is shown in the diagram.

(2)

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- (b) Describe how soya bean plants can be genetically modified to produce large numbers of GM soya bean plants.

(4)

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- (c) Some plants have been genetically modified to express viral antigens.

These plants are used as edible vaccines and stimulate immunity when eaten.

Devise an investigation that a scientist could use to measure the effectiveness of this vaccine in mice.

(5)

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- 8** Vaccines are being developed to stimulate the immune response to destroy cancer cells.

Some of these vaccines contain mRNA that codes for specific antigens found on cancer cells.

- (a) These vaccines deliver the mRNA into antigen presenting cells, such as macrophages.

Describe how the delivery of mRNA into macrophages results in antigen presentation by these cells.

(4)

- (b) Antigen presentation results in the stimulation of both the humoral immune response and the cell-mediated immune response.

Compare and contrast the humoral immune response with the cell-mediated immune response.

(4)

- (c) These vaccines stimulate both the humoral immune response and the cell-mediated immune response.

Explain how the products of these responses result in the destruction of cancer cells.

(4)

5 Turner's syndrome (TS) results from a chromosome mutation.

People with TS are at a higher risk of developing autoimmune disorders than people without TS.

An autoimmune disorder results when a person's immune system attacks their own body.

(a) Which of the following describes the chromosome mutation that causes TS?

(1)

- ☐ **A** non-disjunction leading to monosomy
- ☐ **B** non-disjunction leading to polysomy
- ☐ **C** translocation leading to monosomy
- ☐ **D** translocation leading to polysomy

(b) There were 613 936 babies born in the UK in 2020.

The ratio of baby boys to baby girls is 1.05 : 1.

The incidence of TS is between 1 in 2 000 and 1 in 2 500 in baby girls.

Calculate the **minimum** number of baby girls born with TS in the UK in 2020.

(2)

Answer

(c) Scientists studied a group of girls with TS and a group of girls without TS.

They recorded physical features and immunological markers such as antibodies and lymphocytes.

(i) Girls who had recently been vaccinated were excluded from this study.

Explain why these girls were excluded.

(3)

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(ii) The table shows some of the physical features of the two groups of girls.

Physical features	Mean value ± SD for each group of girls	
	With TS	Without TS
Age / years	11.9 ± 4.1	12.5 ± 4.0
Mass / kg	36.7 ± 14.8	45.2 ± 19.3
Height / cm	134.8 ± 20.0	146.3 ± 21.3
Standardised height score	−2.16 ± 0.95	−0.41 ± 0.50
Body mass index (BMI)	19.2 ± 3.3	19.7 ± 4.6

Only one of these features was significantly different between the two groups of girls.

Explain which was the significantly different feature.

(2)

(iii) The table shows the levels of four immunological markers in the blood of each group of girls.

Immunological marker	Mean value ± SD for each group of girls	
	With TS	Without TS
IgA antibody / g dm ⁻³	1.08 ± 0.39	1.15 ± 0.42
IgG antibody / g dm ⁻³	9.14 ± 2.10	11.15 ± 3.29
CD4 lymphocytes / cells per µl	656.3 ± 227.3	817.3 ± 350.1
CD8 lymphocytes / cells per µl	597.6 ± 272.6	494.8 ± 188.3

Analyse the data to describe the conclusions that can be made about the immunological markers in girls with TS.

(2)

(iv) The scientists also determined the number of a type of cell called T regulatory cells in the blood of these two groups of girls.

They found that the numbers of these cells were very similar.

People with autoimmune diseases have been shown to have a decreased number of T regulatory cells.

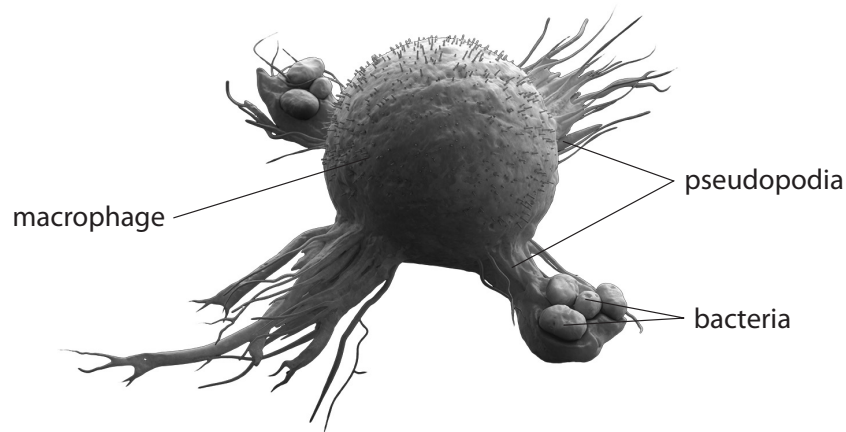
Explain how this study could be modified to show that a decreased number of T regulatory cells is linked to the risk of autoimmune disease in girls with TS.

(2)

7 Macrophages are involved in response to infection.

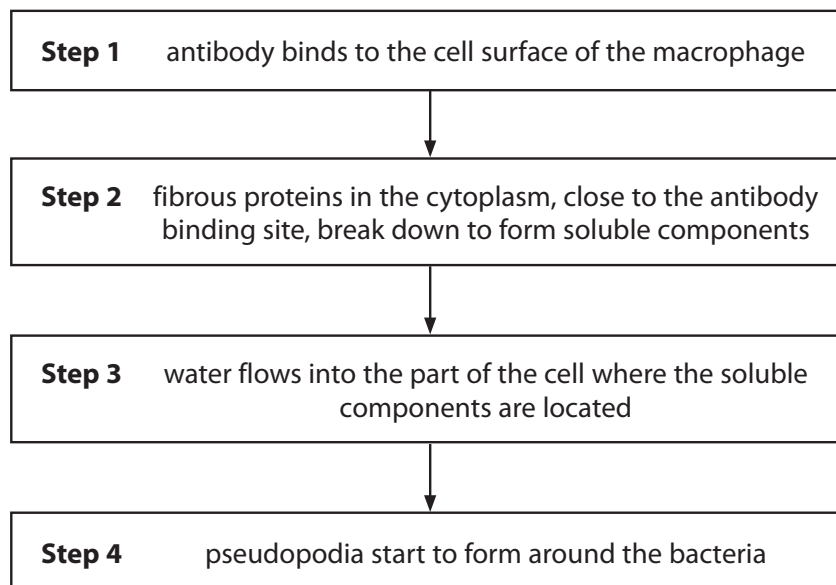
(a) Macrophages engulf bacteria by surrounding the bacteria with pseudopodia.

The image shows a macrophage forming pseudopodia around some bacteria.



(Source: © urfin/Shutterstock)

The flow chart shows one theory for the formation of pseudopodia.



- (i) Which diagram shows one antibody binding to the surface of a macrophage (**Step 1**)?

(1)



- (ii) Actin is a fibrous protein.

Which row of the table describes the breakdown of actin (**Step 2**)?

(1)

	monomer formed	process by which bond is broken
☐ A	amino acid	condensation
☐ B	amino acid	hydrolysis
☐ C	nucleotide	condensation
☐ D	nucleotide	hydrolysis

- (iii) Explain why water flows into the part of the cell where the soluble components are located (**Step 3**).

(2)

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(iv) Describe the events that take place resulting in T helper cell activation, following the formation of pseudopodia by the macrophages (**Step 4**).

(3)



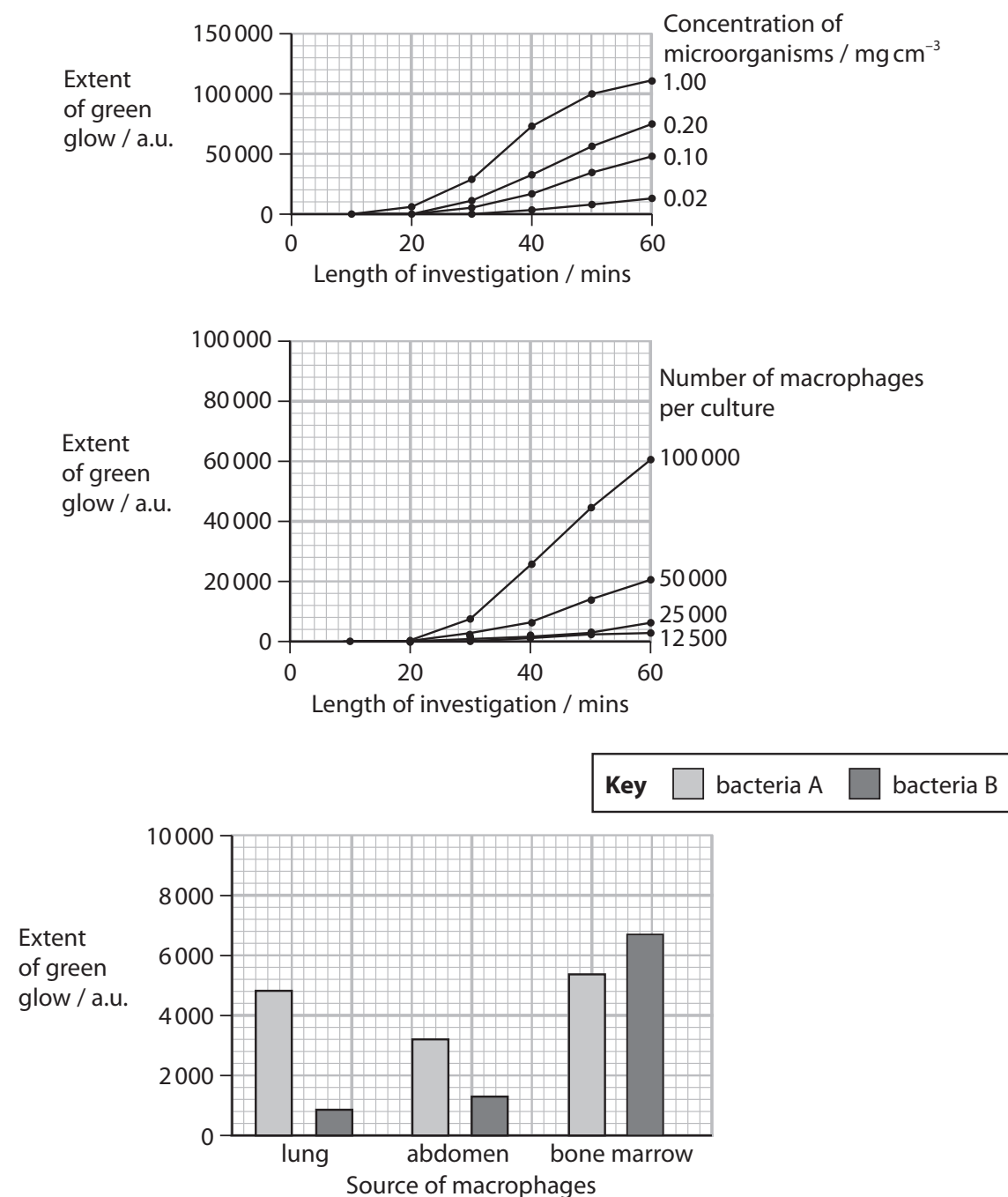
*(b) Phagocytosis by macrophages is affected by a number of factors.

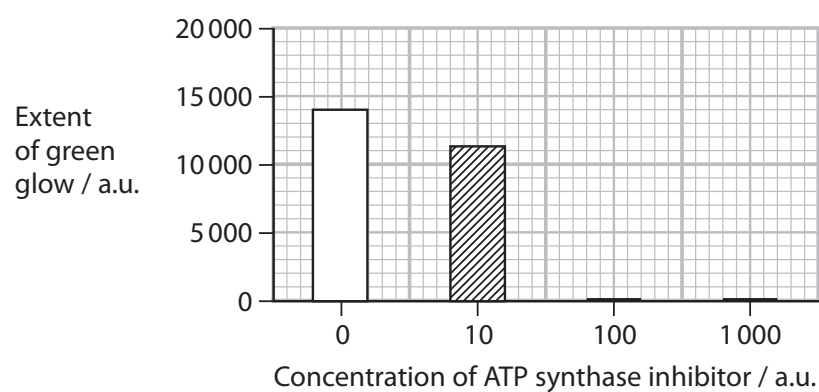
Microorganisms with a fluorescent green dye attached to them were used to measure phagocytosis by macrophages.

The microorganisms were added to the macrophages and incubated. The macrophages were then washed and the extent to which they glowed green was determined.

The extent of the green glow is proportional to the number of microorganisms engulfed by the macrophages.

The graphs show the results of investigations into phagocytosis by macrophages.





Analyse the data to discuss the factors that affect phagocytosis by macrophages.

(6)

7 Malaria is caused by *Plasmodium*, a pathogenic microorganism.

Vaccination is one of many methods being used to control malaria.

In a study, the effectiveness of a vaccine for malaria was tested.

The following method was used:

- samples of *Plasmodium* were exposed to radiation and used to make a vaccine
- two groups of people, A and B, were given different doses of the vaccine
- a third group of people, C, was used as a control
- one month after vaccination, all three groups of people were exposed to mosquitoes known to contain live *Plasmodium*
- the number of people in each group with malaria was recorded.

The results are shown in the table.

Group	Treatment with the vaccine	Number of people in each group	Number of people with malaria
A	low dose	17	16
B	high dose	6	0
C	control	12	11

(a) (i) Explain why the samples of *Plasmodium* were exposed to radiation.

(2)

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(ii) State the control treatment that was given to people in group C.

(1)

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(iii) It was claimed that this vaccine was 100% effective.

Analyse the data to criticise the validity of this claim.

(3)

(iv) Describe how vaccination enabled the people in group B to have active artificial immunity against malaria.

(5)

(b) Anti-malarial drugs can be used to protect people from malaria.

These drugs are not always effective because *Plasmodium* develop resistance.

Explain how drug-resistant *Plasmodium* may evolve.

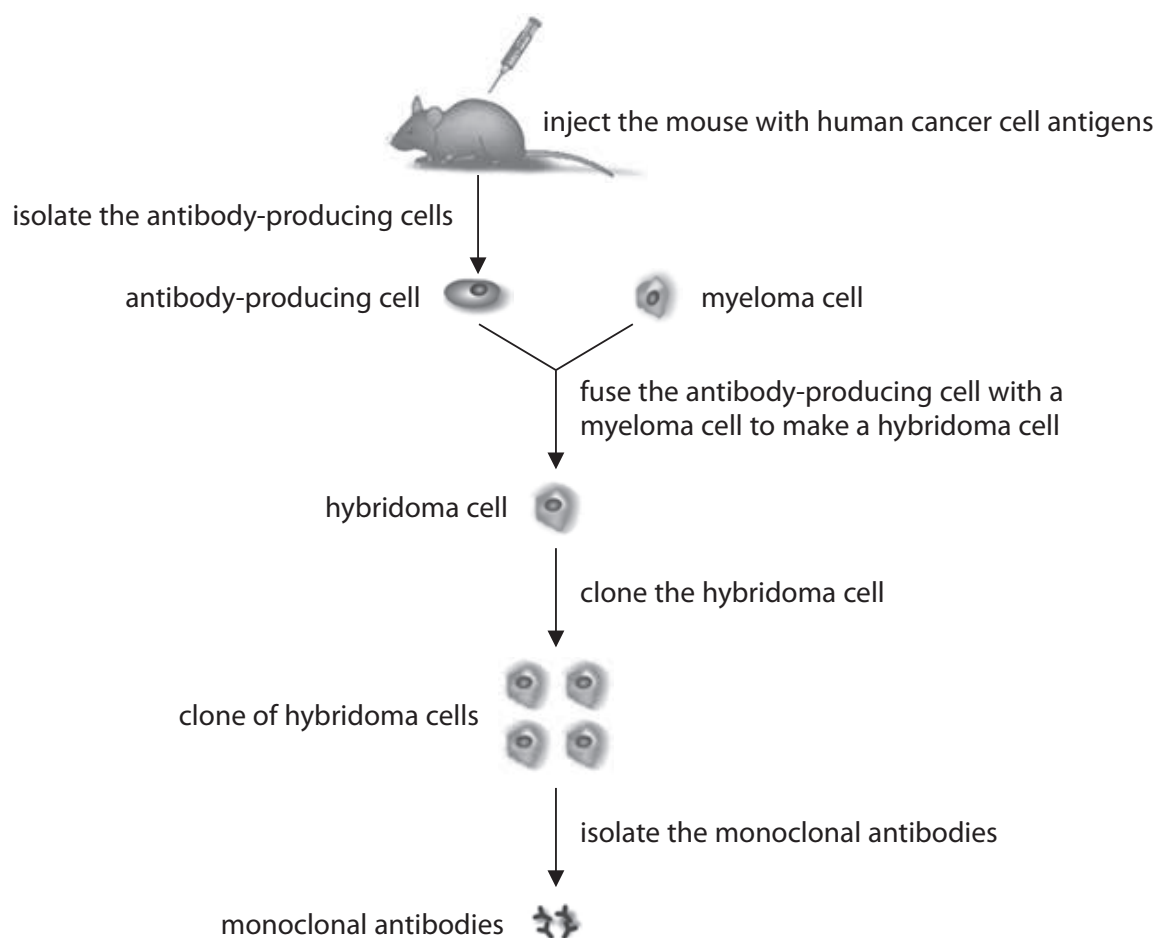
(3)



- 9 Monoclonal antibodies can be made against a wide range of different antigens. They are used in research and medicine.

Monoclonal antibodies are made by fusing an antibody-producing cell with a myeloma cell.

The diagram shows some of the steps involved in making monoclonal antibodies against human cancer cell antigens.



(a) What is the name of the antibody-producing cell?

(1)

- ☐ A macrophage
- ☐ B memory cell
- ☐ C neutrophil
- ☐ D plasma cell

(b) Epigenetic modification is involved in the formation of the antibody-producing cells.

Describe epigenetic modification.

(3)

(c) Myeloma cells have the potential to divide indefinitely.

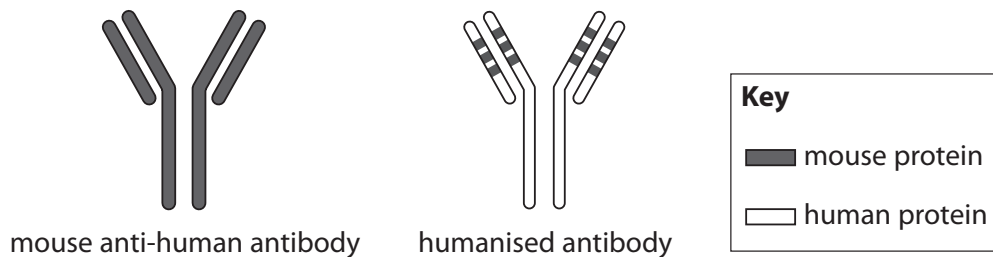
Explain why myeloma cells are used in the production of monoclonal antibodies.

(2)

- (d) The antibodies made by this method are called 'mouse anti-human antibodies'. These antibodies are made by a mouse but are specific to human antigens.

Mouse anti-human antibodies are humanised using recombinant DNA methods.

The diagram shows a mouse anti-human antibody and a humanised antibody.



- (i) Explain the advantages of using humanised antibodies in the treatment of cancer.

(3)

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- *(ii) Explain why mouse anti-human antibodies need to be humanised in order to treat cancer.

(6)

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8 Infections caused by *Chlamydia* and human papillomavirus (HPV) are sexually transmitted.

The HPV is a non-enveloped DNA virus.

Chlamydia infection is caused by the bacterium, *Chlamydia trachomatis*.

(a) Compare and contrast the structure of a bacterial cell with the structure of HPV.

(3)

(b) Some people with HPV infections have no symptoms but others develop warts and some types of cancer.

Over 99% of cervical cancers are caused by HPV.

Girls in the UK are offered an HPV vaccine.

(i) Explain how an HPV vaccine protects girls from developing cervical cancer.

(3)

(ii) Explain why the HPV vaccine will not protect girls from infection with *Chlamydia*.
(3)

*(iii) The HPV vaccination programme is being extended to boys.
Explain the advantages of offering the HPV vaccine to boys, as well as girls, in schools.
(6)

SUB-TOPIC 6(d)

ANTIBIOTICS AND ANTIBIOTIC RESISTANCE

7 questions in this sub-topic · 77 marks · lowest tariff first



2 Enzymes are catalysts that are sensitive to changes in temperature.

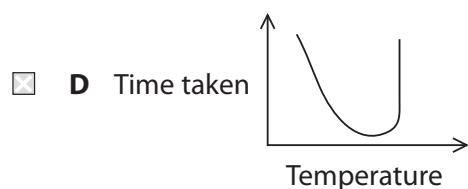
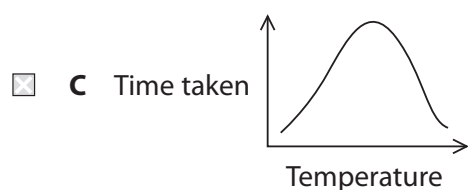
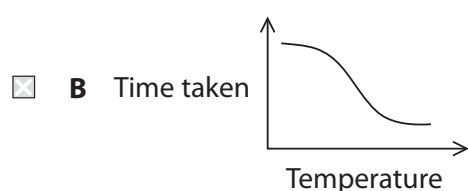
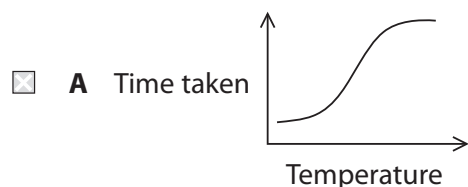
(a) The effect of temperature on the activity of a mammalian enzyme was investigated.

The enzyme was added to a known concentration of the substrate.

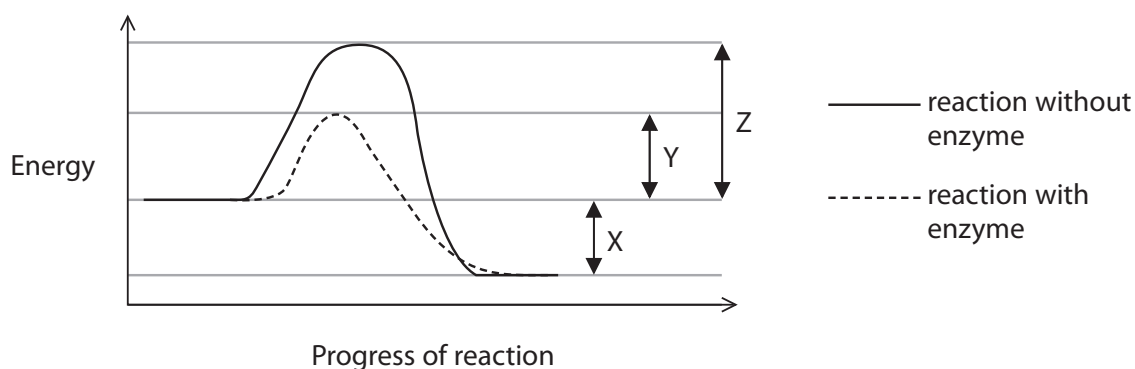
The time taken for all of the substrate to be used up was recorded at several temperatures.

(i) Which graph shows the results of this investigation?

(1)



(ii) The graph shows the energy changes during a reaction with and without an enzyme.



Which of the following represents the decrease in the activation energy of this reaction?

(1)

- ☐ **A** X
- ☐ **B** $X + Y$
- ☐ **C** Z
- ☐ **D** $Z - Y$

(b) Some antibiotics affect the enzymes involved in the growth of bacteria.

- (i) Explain why Gram positive bacteria and Gram negative bacteria react differently to some antibiotics.

(3)

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- (ii) Explain why viruses are not affected by antibiotics.

(2)

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- 1 A problem that has developed in recent years is the emergence of bacteria that are resistant to some antibiotics.

(a) (i) Which of the following will lead to fewer resistant bacteria?

(1)

- ☐ **A** antibiotics being given to farm animals to prevent disease
- ☐ **B** doctors only prescribing antibiotics that are effective against the pathogen
- ☐ **C** doctors only prescribing antibiotics for viral infections
- ☐ **D** patients stopping taking the antibiotics when they feel better

(ii) Which of the following would cause an increase in resistant bacteria?

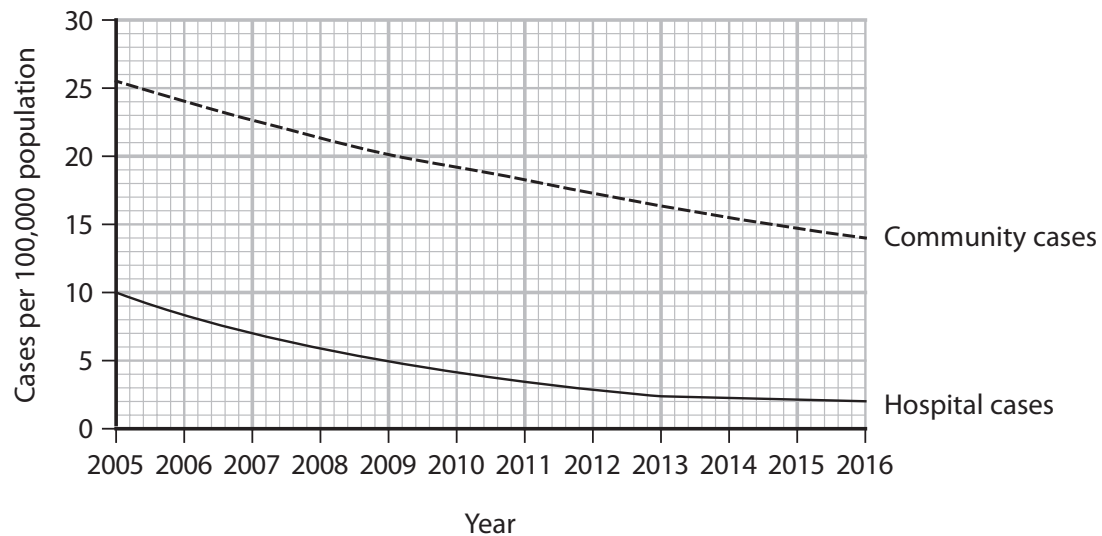
(1)

- ☐ **A** antibiotic use leads to increased competition between bacteria
- ☐ **B** the antibiotic reducing the frequency of mutations in the bacteria
- ☐ **C** the resistant bacteria being killed by the antibiotic
- ☐ **D** the resistant bacteria surviving the antibiotic



- (b) The bacteria referred to as MRSA are resistant to many antibiotics.

The graph shows the number of cases of MRSA in several US states from 2005 to 2016.



- (i) Explain why the number of hospital cases of MRSA is lower than the number of community cases of MRSA.

(2)

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- (ii) Explain the changes in hospital cases and community cases from 2012 to 2016.

(2)

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(c) Describe how DNA sequencing of pathogens may help doctors to prescribe antibiotics more effectively.

(2)



1 Antibiotics are widely used to treat infections.

Some antibiotics are bactericidal.

(a) State what is meant by the term bactericidal.

(1)

(b) The table shows information about five antibiotics.

Antibiotic	Year discovered	Time for first resistant strain of bacteria to be detected / years	Number of different types of each antibiotic that exist today
Penicillin	1928	1	>18
Tetracycline	1945	3	>16
Vancomycin	1953	27	1
Linezolid	1978	1	1
Daptomycin	1985	2	1

Analyse the data to comment on the number of types of each antibiotic that exist today.

(5)

(c) Describe how you would use aseptic techniques to transfer bacterial cells growing on an agar plate to a tube containing a sterile broth.

(5)



7 Bacteria are becoming increasingly resistant to antibiotics.

Controlling the spread of antibiotic resistance is necessary.

(a) Many types of bacteria are resistant to penicillin and tetracycline.

(i) Which row of the table shows the part of a bacterial cell affected by these antibiotics?
(1)

	Penicillin	Tetracycline
☐ A	cell wall	cell wall
☐ B	cell wall	ribosome
☐ C	ribosome	cell wall
☐ D	ribosome	ribosome

(ii) Which row of the table describes the action of penicillin and tetracycline?

(1)

	Penicillin	Tetracycline
☐ A	bactericidal	bactericidal
☐ B	bactericidal	bacteriostatic
☐ C	bacteriostatic	bactericidal
☐ D	bacteriostatic	bacteriostatic

- (b) One method of controlling the spread of antibiotic resistance is to avoid unnecessary prescriptions of antibiotics.

The table shows some illnesses and whether a prescription for antibiotics is recommended.

Illness	Antibiotic prescription
Bronchitis	may be recommended
Ear infection	may be recommended
Influenza	not recommended
Fluid in the ear	not recommended
Strep throat	recommended
Urinary tract infection	recommended

Explain why these recommendations could reduce the spread of antibiotic resistance.

(2)

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- (c) In an investigation, *E.coli* bacteria were isolated from animals reared for food and from some wild animals.

The mean percentage of the *E. coli* isolated from each type of animal that were resistant to different types of antibiotics was determined.

The table shows the results of this investigation, where n is the number of each type of animal.

Antibiotic	Mean percentage of resistant <i>E.coli</i> isolated from animals reared for food (%)			Mean percentage of resistant <i>E.coli</i> isolated from wild animals (%)	
	Broiler chicken n = 45	Village chicken n = 45	Cattle n = 12	Bat n = 13	Rodent n = 35
Ampicillin	50.00	8.89	8.33	0.00	8.57
Cephalothin	14.29	8.89	8.33	20.00	14.58
Chloramphenicol	46.43	0.00	0.00	0.00	0.00
Neomycin	50.00	2.22	25.00	0.00	5.71
Tetracycline	95.86	55.56	25.00	0.00	2.86

- (i) Calculate the ratio of tetracycline-resistant *E.coli* in all the chickens to tetracycline-resistant *E.coli* in cattle.

(2)

Answer

- (ii) There was a total of 2×10^8 *E.coli* isolated from cattle and 6×10^9 *E.coli* isolated from rodents.

Calculate how many more *E.coli* are resistant to cephalothin in rodents than in cattle.

(2)

Answer



(iii) Antibiotics can be added to animal feed.

It is thought this use of antibiotics has contributed to the spread of antibiotic resistance.

Evaluate the extent to which the results of this investigation support this idea.

(4)



8 Cysteine proteases are enzymes found in fruits such as pineapples.

When a protease enzyme is added to fat-free skimmed milk, the milk turns from cloudy to clear.

- (a) Devise an investigation to find the optimum temperature for the activity of the enzyme cysteine protease found in pineapples.

(6)



- (b) Cysteine proteases are also found in the predatory bacterium *Bdellovibrio bacteriovorus* (BvB).

These bacteria are harmless to humans but prey on Gram negative bacteria.

- (i) Give two differences between Gram negative and Gram positive bacteria.

(2)

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- (ii) The cell of the predatory BvB is $1\mu\text{m}$ in length and can swim 100 times its length per second.

Calculate the swimming speed of this bacterial cell in mm s^{-1} .

(2)

Answer



(iii) The BvB bacteria have been described as 'living antibiotics'.

Explain why the BvB bacteria might be useful in the future for treating bacterial infections.

(2)



7 Turmeric is a spice made from the root of the plant *Curcuma longa*.

It has been used in traditional medicine for many years.

- (a) A student investigated the antibacterial properties of turmeric.
The student suggested the hypothesis:

An extract made from turmeric root will reduce the growth of bacteria.

Devise a valid method to test this hypothesis.

(6)

- (b) Curcumin is an organic compound found in the spice turmeric and may be used to treat joint pain.

In 2019, a trial compared the treatment of joint pain with curcumin and Drug A. Joint pain is due to inflammation and can lead to immobility.

This trial involved 139 patients aged 38 to 65, who had been taking anti-inflammatory medication to combat pain for at least three months. These patients were randomly assigned into two groups.

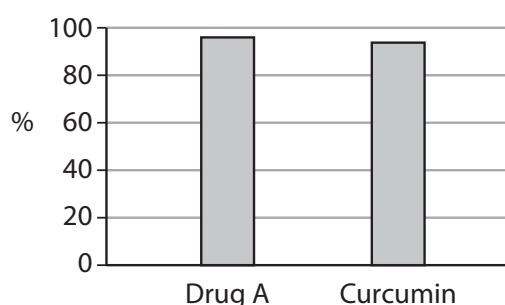
- One group was given 50 mg of Drug A (an anti-inflammatory drug which is an existing treatment for knee pain) twice a day for 28 days.
- The other group was given 500 mg of curcumin three times a day for 28 days.

At the end of the trial, patients were asked to rate their pain on a scale of 0 to 100. The scientists also collected data about side effects, weight loss and overall outcomes.

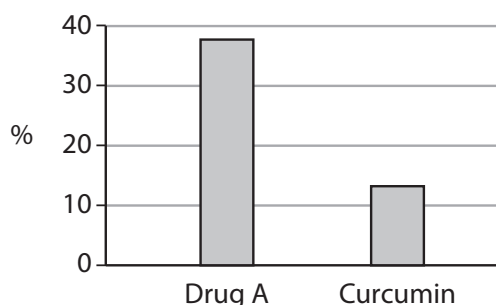
Patients who had liver or kidney disease, heart disease, bronchitis or stomach ulcers were excluded from the trial.

The graphs show the results of this trial.

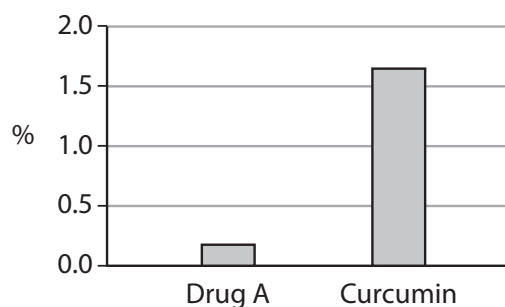
Percentage (%) of patients who reported at least 50% improvement in pain levels at day 28



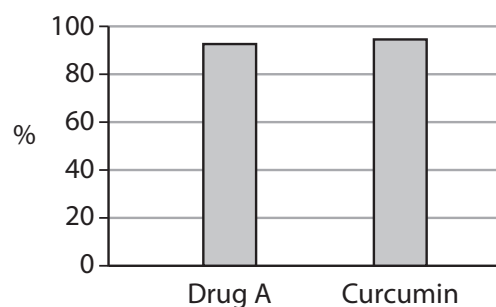
Percentage (%) of patients who reported side effects, including nausea and vomiting



Mean percentage (%) weight loss reported in each treatment group



Percentage (%) of patients rated as having excellent or good outcomes by doctors



Analyse the data to discuss the suggestion that curcumin should be used to replace Drug A as a treatment for knee pain.

Use information about the design of this trial **and** the results to support your answer.

(6)



10 Antibiotics can affect bacteria.

The table describes the mode of action of four antibiotics.

Antibiotic	Mode of action
benzylpenicillin	disrupts peptidoglycan structure
streptomycin	binds to 70S ribosomes
ciprofloxacin	inhibits enzymes involved in prokaryotic DNA replication
rifamycin	inhibits prokaryotic RNA polymerase

(a) (i) Name the antibiotic that affects Gram positive bacteria only.

(1)

(ii) Give one reason why these antibiotics will not affect human cells.

(1)

(b) Explain how rifamycin prevents the growth of bacteria.

(3)



(c) Mutations in the DNA of bacteria can enable them to be resistant to antibiotics.

(i) A single bacterium can produce 2×10^{10} new cells per day by cell division.

The mean mutation rate in one day is 1 in 10 million new cells produced.

Calculate the mean number of bacteria with mutations that could be produced in one day from a single bacterium.

(2)

Answer

(ii) Explain how bacteria may become resistant to streptomycin if a mutation changes the primary structure of a protein.

(3)

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(d) A student compared the effectiveness of these four antibiotics on the growth of bacteria.

Devise a method that the student could use to obtain valid results.

(5)

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MARK SCHEMES

official Pearson Edexcel mark schemes

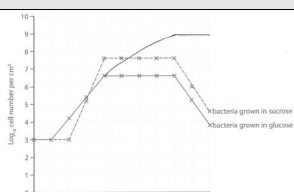


Question Number	Answer	Additional Guidance	Mark
2(a)	B monosaccharide disaccharide	A is incorrect because sucrose is a disaccharide C is incorrect because glucose is a monosaccharide D is incorrect because glucose is a monosaccharide and sucrose is a disaccharide	

Question Number	Answer	Additional Guidance	Mark
2(b)(i)	- values read from graph per unit time and converted back from logs - subtraction of each pair and division done	$(7.6 - 3.9) / 10 = 0.37$ $(6.6 - 3.9) / 10 = 0.27$ $(3.0 - 3.9) / 10 = -0.09$ or $(4.2 - 3.9) / 10 = 0.03$ $15 / 10 = 1.5$ ACCEPT 1.9 / 1.92 / 2 / 82.5 / 82.54 / 83 for 1 mark if slopes of graph used but no mention of the exponential growth rate constant (k)	

	OR exponential growth rate constant (k) calculated and used	ACCEPT k values calculated (3.820598 / 3.82 and 1.99335548 / 1.99) for 1 mark and k sucrose divided by k glucose = 1.9 / 1.92 / 2 for 2 marks	
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Question Number	Answer	Additional Guidance	Mark
2(b)(ii)	An explanation that makes reference to the following: (lag phase longer as) {sucrose has to be broken down / enzymes to breakdown sucrose had to be synthesised} (1) (reproduction faster) because sucrose has more {sugar / monosaccharides / energy} (1)	ACCEPT converse for glucose ACCEPT sucrase ACCEPT sucrose made of glucose and fructose / sucrose is a disaccharide and glucose is a monosaccharide	

Question Number	Answer	Additional Guidance	Mark
2(b)(iii)	a line that continues to go up after 8 hours and then levels off (around) 16 hours without dropping		

Question Number	Answer	Additional Guidance	Mark
3(a)(i)	The only correct answer is A B is incorrect because bacteria have 70S ribosomes C is incorrect because bacteria do not have a nucleus D is incorrect because bacteria do not have a nucleus or 80S ribosomes		(1)

Question Number	Answer	Additional Guidance	Mark
3(a)(ii)	An answer that makes reference to the following: - cytoplasm - plasmids - cell membrane	3 correct = 2 marks 1 or 2 correct = 1 mark ACCEPT glycogen granules / lipid droplets / mesosome	(2)

Question Number	Answer	Additional Guidance	Mark
3(b)(i)	23 : 1.0	Accept 23 : 1 Accept 1.0 : 0.043 Accept 1 : 0.043	(1)

Question Number	Answer	Additional Guidance	Mark
3(b)(ii)	An explanation that makes reference to the following: <i>B. subtilis</i>, because it {is Gram positive / has a thick peptidoglycan cell wall} (1) - antibiotics interfere with the synthesis of peptidoglycan (crosslinks) / inhibit formation of peptidoglycan (1)		(2)

Question Number	Answer	Additional Guidance	Mark
3(c)	An answer that makes reference to the following: - increase in cell number calculated (1) - rate calculated (1)	$(1.7 \times 10^5 - 6 \times 10^3 =) 164\,000$ 1367 / 1366.7 / 1366.67 / 1366 recurring (cells per minute) 1366(.66) gains 1 mark Correct answer with no working gains 2 marks	(2)

Question Number	Answer	Mark
8(a)	The only correct answer is C <i>A is not correct because Salmonella are gram negative bacteria so will have a thin peptidoglycan cell wall</i> <i>B is not correct because Salmonella are gram negative bacteria so will have a thin peptidoglycan cell wall and they produce endotoxins</i> <i>D is not correct because Salmonella produces endotoxins</i>	(1)

Question Number	Answer	Additional Guidance	Mark
8(b)(i)	An explanation that makes reference to four of the following: - medium allows only {<i>Salmonella</i> / certain bacteria} to grow (1) {culture / colonies / bacteria} is spread out on the {agar / medium} (1) - because this separates out individual bacteria (1) - so that colonies are {discrete / separate / individual} (1) - so only one type of {bacteria / colony} can be picked up (1)	ACCEPT in context of {named media / antibiotic-containing media}	(4)

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	- log of the values taken (1) - substitution of values into equation (and evaluating correctly) (1) - k given to an appropriate number of decimal places (1)	$\log 5 \times 10^3 = 3.6989700043$ and $\log 4 \times 10^6 = 6.6020599913$ $(6.6020599913 - 3.6989700043) \div (0.301 \times 10) = 0.9644817233$ ACCEPT correct value for rounded up values substituted 0.964 / 0.96 CE applies from mp 1 only	(3)

Question Number	Answer	Additional Guidance	Mark
8(b)(iii)	An explanation that makes reference to the following: - the value for t used in the calculated value is greater than the actual value (1) - therefore the calculated value for k will be smaller (1) - because the <i>Salmonella</i> will not be replicating (in lag phase) (1)	ACCEPT converse for actual value ACCEPT converse for actual value ACCEPT dividing / growing	(3)

Number	Answer	Additional Guidance	Mark
5(a)(i)	A description that includes two of the following: - prokaryotes have a loop of DNA but eukaryotes have linear chromosomes (1) - prokaryote cell wall contains {peptidoglycan / teichoic acid / murein}, but eukaryote cell wall does not (1) - prokaryotes do not have a nucleus but eukaryotes do (1) - prokaryotes do not contain membrane-bound organelles, but eukaryotes do (1) - prokaryotic cells (only) have 70S ribosomes, but eukaryotic cells have {80S ribosomes / have both 70S and 80S} (1)	Accept prokaryotes have one {piece of DNA / chromosome}, but eukaryotes have several chromosomes Accept in eukaryotes DNA is associated with histone proteins but not in prokaryotes Ignore references to plasmids Accept eukaryote cell wall (if present) contains {cellulose / chitin}, but prokaryote cell wall does not Accept all prokaryotic cells have a cell wall but some eukaryotic cells do not have a cell wall Accept eukaryotes have a nucleus but prokaryotes have {a nucleoid / DNA in cytoplasm} Accept named organelle eg mitochondria / chloroplasts / Golgi body Accept prokaryotic ribosomes are smaller than those in eukaryotic cells / prokaryotic ribosomes have subunits 30S and 50S, but eukaryotic ribosomes have subunits 40S and 60S	(2)

Question Number	Answer	Additional Guidance	Mark
5(a)(ii)	An explanation including two of the following - bacteria are Gram negative (the cell wall has) {a thin peptidoglycan layer / an outer membrane / lipopolysaccharide layer} (1) - so it does not retain violet / blue stain (but picks up red stain) (1) and - so helps to determine which antibiotics {are used / will be most effective} (to treat infection) (1)	Accept - ve Accept {less / little} peptidoglycan Accept {primary stain / crystal violet} for blue stain Accept {outer membrane / lipopolysaccharide} is a barrier to some antibiotics Ignore ref to {bactericidal / bacteriostatic / exotoxins / endotoxins} and focus on choosing antibiotic Ignore determining dose of antibiotics	(3)

Question Number	Answer	Additional Guidance	Mark
5(b)(i)	A description including four of the following • use of inoculating loop to transfer bacteria (to nutrient agar) (1) • {description / diagram} of streak plating (1) • incubation for suitable period (1) • incubation at suitable temperature (1) • identification of {bacteria / colonies} by {colour / shape} (1) • transfer to separate agar plates (1)	Accept description of loop eg wire Accept use of loop to transfer from {culture / broth} Accept {24-48 hours / stated time in range} Accept {20-37 °C / stated temperature in range / below 37 °C / below 30 °C / stated temperature below this value} Accept identification of {colonies / bacteria} by microscopy Accept use of selective media to identify {colonies / bacteria} Accept description of transfer	(4)

Question Number	Answer	Additional Guidance	Mark
5(b)(ii)	An explanation including three of the following • use of aseptic technique to prevent {contamination / growth of pathogens} (1) • example of aseptic technique with appropriate explanation (1) • incubation below 30 °C, as {this is below optimum for pathogens / pathogens are more likely to grow at 37 °C} (1) • use of cross tape between lid and base, to {allow air to enter / prevent growth of anaerobes} (1)	Accept example of aseptic technique eg • autoclaving {to kill bacteria / so no pathogens present} • use of sterile equipment to prevent contamination • flaming {inoculation loops / neck of bottle} to kill bacteria • working near lit Bunsen to {create an updraft / carry bacteria away from plate} • partially opening lids of plates to prevent entry of bacteria • disinfection of surfaces to {kill / remove} bacteria Accept stated temperature below 30 °C Accept not sealing lid to base of plate to {allow air to enter / prevent growth of anaerobes}	(3)

(Total for Question 5 = 12 marks)

Question Number	Answer	Additional Guidance	Mark
8(a)(i)	A description that makes reference to four of the following: - sample taken from the female genital tract (1) - bacteria grown on {selective / indicator} media (1) - bacteria grown on media containing different types of antibiotics (1) - use of {antibodies / DNA profiling} (1) - using {Gram staining / cell shape / colony shape / colony colour} (1)		(4)

Question Number	Answer	Additional Guidance	Mark
8(a)(ii)	An explanation that makes reference to three of the following: - because they grow on the skin cells preventing pathogenic bacteria from doing so (1) - because they use the glycogen so less {glucose / energy / glycogen} available for the pathogenic bacteria (1) - because they produce lactic acid which inhibits the growth of pathogenic bacteria (1) - because the low pH denatures the enzymes of the pathogenic bacteria (1)	ACCEPT below optimum pH	(3)

Question Number	Answer	Additional Guidance	Mark
8(b)(i)	An answer that makes reference to three of the following: Similarities - both {are hexoses / have formula of $C_6H_{12}O_6$} (1) - both contain covalent bonds (1) Differences - glucose is a hexagon and fructose is a pentagon (1) - glucose has one CH_2OH and fructose has two (1)	ACCEPT have 6 carbons	(3)

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	An explanation that makes reference to the following: - as a {respiratory substrate / energy source} for the sperm (1) - because movement (through female genital tract) requires ATP (1) - in order to reduce competition for carbohydrates with the {skin / genital tract} {bacteria / cells} (1)	ACCEPT provides energy NB ATP must be mentioned at least once for both mps to be awarded ACCEPT fructose may not be used by skin cells	(3)

Number	Answer	Additional Guidance	Mark
11(a)(i)	An answer that includes the following: - correct conversion of dilution factor (1) - correct number of bacteria calculated, given in standard form (1)	Sample calculation (126 x 10³ gives) 126 000 / 1.26 x 10⁵ / 1.3 x 10⁵ Accept (13 x 10⁴ =) 130 000 / 1.3 x 10⁵ (1 x 10⁵ =) 100 000 / 1 x 10⁵ Accept mean value ie 128 000 / 1.28 x 10⁵ / 1.3 x 10⁵ 118 667 / 1.19 x 10⁵ / 1.2 x 10⁵ (126 000 x 2 =) 2.52 x 10⁵ / 2.5 x 10⁵ (per cm³) Accept (130 000 x 2 =) 2.6 x 10⁵ (100 000 x 2 =) 2 x 10⁵ (128 000 x 2 =) 2.56 x 10⁵ / 2.6 x 10⁵ (118 667 x 2 =) 2.37 x 10⁵ / 2.4 x 10⁵ Correct answer with no working gains full marks Correct answer not in standard form gets 1 mark 252 000 / 260 000 / 200 000 / 256 000 / 237 334	(2)

Question Number	Answer	Additional Guidance	Mark
11(a)(ii)	An explanation that includes four of the following: {lag phase / 0 to 1.3 hours} increase is slow as {bacteria are adjusting to conditions / enzymes are being synthesised / cells increase in size} (1) {log phase / 1.3 to 4.7 hours} increase is {exponential / very rapid} as conditions are ideal for bacteria (1) {stationary phase / 4.7 to 9.7 hours} number of bacteria remains constant because {{nutrients / named nutrient} begin to run out / toxins start building up / pH decreases} (1) {death phase / 9.7 hours to 11 hours} number of bacteria decreases (as they die) due to build up of {toxins / waste products}	Accept very little change in numbers Allow acclimatise Accept nothing slowing down division competition is not too high named example of ideal conditions (eg nutrients) Accept {number of new cells formed / reproduction rate} is equal to {number of cells dying / death rate} for constant Allow competition for resources Ignore birth rate = death rate Accept death rate greater than reproduction rate for decreases Accept {build-up of carbon dioxide / decreased pH / lack of nutrients} (causes cell death)	(4)

Question Number	Answer	Additional Guidance	Mark
11(a)(iii)	An answer that includes the following: - correct substitution of values into equation (1) - correct calculation of k to 2dp (1)	Example of calculation $\frac{5.01 - 2.6}{3.4 \times 0.301}$ 2.35 Correct answer to wrong number of dp gets 1 mark Ignore units Correct answer with no working gains full marks	(2)

Question Number	Answer	Additional Guidance	Mark
11(a)(iv)	An answer that includes the following: correct calculation of g (1)	Example of calculation Allow ecf from 11(a)(iii) $g = \frac{60}{2.35} = 25.53 / 25.532 / 25.5$ Accept maximum of 3dp	(1)

Question Number	Answer	Additional Guidance	Mark
11(b)	An answer that includes four of the following: Serial dilution and plating - allows calculation of {viable / living} bacteria (1) - gives a direct {cell count / number of bacteria} (1) - allows different types of bacteria to be identified (1) - does not need expensive equipment Measurement of turbidity using colorimeter {is relatively easy to carry out / does not require a lot of resources} (1) - results are available immediately (1) - is less likely to be affected by {random / measurement} error (1) - is less likely to be contaminated during process (1)	Credit maximum of 3 from each Accept allows death phase to be counted more accurately / allow the identification of the stationary and death phases Accept does not depend on calibration using another method eg using a haemocytometer eg colorimeter Accept faster Accept human error	(4)

(Total for Question 11 = 13marks)

6 (a)	H / hydrogen		(1)
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Question Number	Answer	Additional Guidance	Mark
6 (b)	An explanation that makes reference to two of the following: {bacteria / microbes} cannot {reproduce / undergo binary fission} (1) (because) complementary base pairing cannot occur (1) (because) mRNA synthesis prevented (1)	Accept bacteria cannot replicate / multiply Accept T cannot pair with A Accept no transcription occurs	(2)

Question Number	Answer	Additional Guidance	Mark
6 (c)	An answer that makes reference to two of the following: {flame / sterilise / autoclave} apparatus to kill bacteria (1) - clean surfaces with {bleach / disinfectant / alcohol} to kill bacteria (1) - open lid of Petri dish slightly to prevent access by bacteria (1) - work near Bunsen flame to {create updraft / prevent bacteria settling} (1)	Accept microbes / spores for all points	(2)

Question Number	Answer	Additional Guidance	Mark
6(d)(i)	An answer that makes reference to three of the following: Similarity - both have peptidoglycan (1) Two differences from: - positive has {more / thicker layer of} peptidoglycan than negative / positive has a thicker cell wall than negative (1) - positive has teichoic acid, negative does not (1) - negative has outer membrane, positive does not (1) - negative (most) has periplasmic space, positive does not (1) - negative has {more lipid / lipopolysaccharide / porin proteins}, positive does not (1)	Accept periplasm	(3)



Question Number	Answer	Additional Guidance	Mark
6(d)(ii)	- subtraction using values from graph (1) - calculation of percentage change (1)	$10^8 - 10^2 = 99\,999\,900$ $\div 10^8 \times 100 = \mathbf{99.9999}$ Correct answer gains full marks, with no working shown.	(2)

Question Number	Answer	Additional Guidance	Mark
6(d)(iii)	An answer that makes reference to the following: - it is effective if irradiation longer than 3 hours (1) - it is effective against E. coli which infect the intestine (1) - not all species of {pathogenic bacteria / bacteria causing food poisoning} investigated / only three types of bacteria investigated (1) - toxins may remain in food (1)	Accept effectiveness depends on how long it is irradiated for	(4)

Question Number	Answer	Additional Guidance	Mark
6(a)(i)	The only correct answer is D A is incorrect because crista are in mitochondria B is incorrect because the photosystems are not in the inner membrane D is incorrect because the photosystems are not in the outer membrane		(1)

Question Number	Answer	Additional Guidance	Mark
6(a)(ii)	• photolysis (1)		(1)

Question Number	Answer	Additional Guidance	Mark
6(a)(iii)	The only correct answer is C A is incorrect because reduced NADP is formed B is incorrect because reduced NADP is formed D is incorrect because an electron is gained when a substance is reduced		(1)

Question Number	Answer	Additional Guidance	Mark
6(a)(iv)	• $\text{ADP} + \text{Pi} \rightarrow \text{ATP}$ (1)	ACCEPT ADP / adenosine diphosphate Pi / phosphate / phosphate ions ATP / adenosine triphosphate Do not accept any other arrow	(1)

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	An answer that makes reference to the following: • Correct value calculated from graph (1) • Answer calculated (1)	$(18.5 - 0.5) \div 14 = 1.28571428571 \times 10^6$ $\div 1.04 \times 10^6 = 1.236$ 1.2 1.3 gains 1 mark Correct answer gains 2 marks	(2)

Question Number	Answer	Additional Guidance	Mark
6(b)(ii)	An explanation that makes reference to the following: • darker green (because synthesis of) {more photosynthetic pigments /more chlorophyll/more chloroplasts} (1) • (more pigments) absorb more light for photosynthesis (1) • cells not increased in number as number of new cells equals number of dying cells /stationary phase (1) • explanation of death phase (1) • credit one reason explained for cells entering death phase (1) • credit second reason explained for cells entering death phase (1)	Accept converse cells in natural light still dividing (by mitosis) e.g more cells are dying than are being produced e.g. limiting factors are: (visible) light minerals/ carbon dioxide build up of toxins/waste in the culture space	(5)

Question Number	Answer	Additional Guidance	Mark
6(b)(iii)	An explanation that makes reference to the following: • <i>Chlorella</i> produce several (different photosynthetic) pigments (1) • therefore {maximises/more} light absorption(1) • therefore {maximises/more} production of electricity (by the solar cells) (1)		(3)

Question Number	Answer	Additional Guidance	Mark
11(a)(i)	- calculation of difference (1) - calculation of % increase (1)	Example of calculation $2400 - 400 = 2000 \qquad 24 - 4 = 20$ $\frac{2000}{400} \times 100 = 500 (\%) \qquad \frac{20}{4} \times 100 = 500 (\%)$ Correct answer with no working gets 2 marks	(2)

Question Number	Answer	Additional Guidance	Mark
11(a)(ii)	correct answer (1)	384 ($\times 10^2$ per cm^3) Accept 360 to 400 ($\times 10^2$ per cm^3)	(1)

Question Number	Answer	Additional Guidance	Mark
11(b)	A description that includes the following: Two relevant techniques to prevent bacterial growth described (2)	eg use of sterile / autoclaved equipment flaming neck of bottle / transfer loops working next to (lit) Bunsen burner disinfection of bench / work surface use of selective medium / antibiotics in medium	(2)

Question Number	Answer	Additional Guidance	Mark
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11(c)(i)	- Correct calculation of number of cells (1) - Conversion to standard form (1)	Example of calculation $\frac{7}{8} \text{ divided by } 0.004 = \frac{1750 \text{ per mm}^3}{2000 \text{ per mm}^3}$ $1.75 / 1.8 / 2 \times 10^3$ Correct answer with no working gets 2 marks	(2)
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Question Number	Answer	Additional Guidance	Mark
11(c)(ii)	An answer that includes two of the following: {yeast cells may not be evenly distributed / sample may not be representative} (1) - yeast cells may be {reproducing / budding / undergoing cell division} (so hard to know whether to count one or two) (1) - difficult to decide if they are touching the sides of the counting square (1)	Accept clumping / overlapping of cells may occur Accept this method counts dead cells (as well as live) Ignore human error / miscounting unqualified	(2)

Question Number	Answer	Additional Guidance	Mark
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11(d)(i)	- calculation of $\sum (x - \bar{x})^2$ (1) - divided by $\{4 / n-1\}$ (1) - calculation of SD (1)	Example of calculation 31.2 7.8 2.8 Correct answer with no working gains 3 marks	(3)
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Question Number			
1(a)(i)	<i>Salmonella</i> (species) (1)	ACCEPT phonetic spellings ACCEPT <i>Shigella</i>, <i>Neisseria</i>, <i>Escherichia</i>, <i>Pseudomonas</i>, <i>Klebsiella</i>, <i>Proteus</i>, <i>Providencia</i>, <i>Escherichia</i>, <i>Morganella</i>, <i>Aeromonas</i>, <i>Citrobacter</i> ACCEPT specific examples e.g. <i>E.coli</i> DO NOT ACCEPT gram positive bacteria e.g. <i>Actinomyces</i>, <i>Clostridium</i>, <i>Mycobacterium</i>, <i>Streptococci</i>, <i>Staphylococci</i>, <i>Nocardia</i>	(1)

Question Number	Answer	Additional Guidance	Mark
1(a)(ii)	gram negative bacteria have {a thinner peptidoglycan cell wall / an (outer) lipopolysaccharide (layer) / an outer membrane} (1)	ACCEPT converse for gram positive bacteria ACCEPT less peptidoglycan murein for peptidoglycan larger periplasm (space) no teichoic acid (in cell wall)	(1)

Question Number	Answer	Additional Guidance	Mark
1(b)(i)	0.308 / 0.31 / 0.3 (1)		(1)

Question Number	Answer	Additional Guidance	Mark
1(b)(ii)	An answer that makes reference to two of the following: - endotoxins released from Gram negative bacteria (only) but exotoxins released from both Gram negative and Gram positive bacteria (1) - endotoxins are lipopolysaccharides but exotoxins are proteins (1) - endotoxins released from {dead / broken down} bacteria but exotoxins are released from living bacteria (1) - effect of endotoxins is later (1)		(2)

Question Number	Answer	Additional Guidance	Mark
3(a)	B <i>Puccinia</i>	A is incorrect because <i>Plasmodium</i> is a protist that causes malaria C is incorrect because <i>Salmonella</i> is a bacteria that causes food poisoning D is incorrect because <i>Staphylococcus</i> is a bacteria that causes food poisoning	

Question Number	Answer	Additional Guidance	Mark
3(b)	An explanation that makes reference to three of the following: (stem rust) fungus {takes up / uses} {nutrients / glucose / amino acids} (1) - less {glucose to form starch / amino acids to form protein} (1) (stem rust) fungus interferes with vascular tissue (1) - consequence of damaged vascular tissue (1)	ACCEPT glucose for respiration (by the plant) e.g. weakened stems , less magnesium ions for chlorophyll, less sucrose to transport to roots	

Question Number	Answer	Additional Guidance	Mark
3(c)	An answer that makes reference to three of the following: - because {meiosis / sexual reproduction / basidiospore production} results in {genetically different fungi / variation} (1) - because of {crossing over / random assortment / independent assortment} (1) - because of mutation (in the DNA) (1) - the {asexual cycle / production of uredinospores} results in more stem rust fungus that plants are not resistant to (1)	ACCEPT recombinants ACCEPT only in the context of causing variation DO NOT ACCEPT meiosis causes mutation ACCEPT clones of stem rust fungus that plants are not resistant to	

Question Number	Answer	Additional Guidance	Mark
3(a)	The only correct answer is A B is incorrect because <i>Plasmodium</i> is the genus name not the species name C is incorrect because <i>Plasmodium</i> causes malaria not <i>Puccinia</i> D is incorrect because <i>Plasmodium</i> causes malaria not <i>Puccinia</i>		(1)

Question Number	Answer	Additional Guidance	Mark
3(b)	A description that makes reference to three of the following: • {gene / DNA / genetic material} coding for toxin isolated (from the spiders) (1) • using {restriction enzymes / (restriction) endonucleases} (1) • (spider) gene inserted into fungus using a {vector / named vector} (1) • genetically-modified fungi {identified / cloned / cultured} (1)	ACCEPT mRNA isolated and used to synthesise the gene / base sequence of gene determined and used to synthesise a gene ACCEPT in context of vector DNA e.g. virus / plasmid / gene gun / injection ACCEPT replicate / reproduce	(3)

Question Number	Answer	Additional Guidance	Mark
3(c)	An explanation that makes reference to three of the following: • not unethical as mosquitoes not killed (1) • risk of other organisms being affected by the genetically-modified fungus is avoided (1) • organisms that feed on mosquitoes will not lose their food supply (1) • some people believe that modifying DNA is {wrong / unethical} (1)	ACCEPT converse for other approach e.g. toxins could harm other organisms, transfer of genes into other organisms ACCEPT unknown risks ACCEPT biodiversity maintained / ecosystems not disrupted / food chain not disrupted	(3)

Question Number	Answer	Mark
4(a)	The only correct answer is A <i>B is incorrect because TMV does not have an envelope</i> <i>C is incorrect because lambda phage is a DNA virus and does not have an envelope</i> <i>D is incorrect because TMV does not have an envelope and lambda phage is a DNA virus and does not have an envelope</i>	(1)

Question Number	Answer	Mark
4(b)	The only correct answer is C <i>A is incorrect because influenza is predominantly transmitted by respiratory droplets and only a few cases by contaminated surfaces</i> <i>B is incorrect because influenza is predominantly transmitted by respiratory droplets</i> <i>D is incorrect because influenza is predominantly transmitted by respiratory droplets</i>	(1)

Question Number	Answer	Additional Guidance	Mark
4(c)	An explanation that makes reference to three of the following: (because it takes time) for {enough / large number of / other} cells to be damaged (by viruses) (to cause the symptoms) (1) Any TWO from: (because time taken) for attachment to host cell (1) (because time taken) for {penetration / infection} of host cell with {virus / RNA / genetic material} (1) (because time taken) for synthesis of RNA (from RNA) (1) (because time taken) for synthesis of proteins (1) (because time taken) for {assembly of (new) viruses / viral components to be put together} (1)	IGNORE refs to retroviruses and latency throughout NB must be a ref to a time delay for all 3 marks to be awarded ACCEPT for {enough / large number of} virus particles to be produced to infect other cells for {the immune system to be activated / an immune response to occur} DO NOT ACCEPT DNA DO NOT ACCEPT DNA IGNORE replicated / produced	(3)

Question Number	Answer	Additional Guidance	Mark
4(d)(i)	1 : 0.30 / 1.00 : 0.30 (1)	ACCEPT 3.35 : 1 / 3.35 : 1.00	(1)

Question Number	Answer	Additional Guidance	Mark
4(d)(ii)	An explanation that makes reference to the following: - because the antibiotics will not work as viruses are not {living / cells} (1) (and unnecessary usage) will act as a selection pressure to {cause / increase} antibiotic resistance (in bacteria) (1)	DO NOT ACCEPT viruses are dead IGNORE antibiotics only target cell wall / viruses do not have a cell wall ACCEPT description of selection pressure e.g. resistant bacteria will survive and non-resistant ones will not DO NOT ACCEPT immune causes mutation	(2)

Question Number	Answer	Additional Guidance	Mark
3(a)(i)	An explanation that makes reference to three of the following: - because the food poisoning was happening {after one hour / within a few hours} of the meal (1) - indicating that exotoxins caused the food poisoning (1) - because endotoxins are only present after {about 12 hours / several hours / when the bacterial cells are destroyed} (1) <i>Staphylococcus</i> releases exotoxins / endotoxins come from <i>Salmonella</i> (1)	Accept soon after meal / quickly / by {12 / 1} o'clock Do not accept <i>Staphylococcus</i> is an exotoxin / <i>Salmonella</i> is an endotoxin	(3)

Question Number	Answer	Additional Guidance	Mark
3(a)(ii)	A description that makes reference to any four of the following: - isolate the bacteria from the {food / patient / faeces / vomit} (1) - look at the colonies to see if they have a {characteristic / named characteristic} (of <i>Staphylococcus</i>) (1) - use Gram stain to show presence of Gram positive bacteria (1) - grow on selective media that identify {<i>Staphylococcus</i> / eliminates other bacteria} (1) - use antibodies against <i>Staphylococcus</i> (1)	Accept a description of how this is done e.g. streak plating from a faecal sample Accept <i>Staphylococci</i> will appear purple with Gram stain Accept differential media / selective agar / named example e.g. mannitol salt agar / with antibiotics	(4)

Question Number	Answer	Mark
3(b)(i)	3(b)(i). The only correct answer is C A is not correct because not all RNA viruses have envelopes and only the retroviruses contain reverse transcriptase B is not correct because only the retroviruses contain reverse transcriptase D is not correct because not all RNA viruses have envelopes and they are not all helical	(1)

Question Number	Answer	Mark
3(b)(ii)	3(b)(ii). The only correct answer is A B is not correct because λ phage has DNA C is not correct because λ phage has DNA D is not correct because λ phage has DNA	(1)

Total for Question 3 = 9 MARKS



Question Number	Answer	Additional Guidance	Mark
3(a)(i)	<i>Anopheles</i>	DO NOT ACCEPT <i>Anopheles gambiae</i>	(1)CL

Question Number	Answer	Mark
3(a)(ii)	The only correct answer is C Order <i>A is incorrect because organisms in orders are sub-divided into families</i> <i>B is incorrect because organisms in families are sub-divided into a genus</i> <i>D is incorrect because organisms in phylum are sub-divided into classes</i>	(1)

Question Number	Answer	Mark
3(a)(iii)	The only correct answer is B <i>Plasmodium falciparum</i> <i>A is incorrect because Anopheles gambiae is the vector and not the pathogen</i> <i>C is incorrect because Puccinia graminis causes stem rust</i> <i>D is incorrect because Salmonella enterica causes food poisoning</i>	(1)

Question Number	Answer	Additional Guidance	Mark
3(b)(i)	An explanation that makes reference to one pair from the following: - mosquito coils / mosquito nets / insect repellent (1) - because {too expensive / not always available} (1) OR - anti-malarial tablets (1) - because {too expensive / not always available / side effects} (1) OR - avoiding stagnant water (1) - because impractical as people's {homes / work} are near stagnant water 1) OR - long clothing (1) - because impractical for working (1) OR	ACCEPT {removing / adding chemicals} to stagnant water ACCEPT affects organisms living in the water	(2)

	- insecticide (1) - expensive / can {poison / kill} other organisms / can affect the food chain (1) OR - sterile insect technique (1) - not fully tested / expensive (1) OR - biological control (1) - can affect the food chain (1)		
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Question Number	Answer	Additional Guidance	Mark
3(b)(ii)	- percentage of deaths in 2015 compared to 2010 (1) - number of deaths in 2010 (1)	<u>Example of calculation:</u> 100 - 29 = 71 429 000 × 100 ÷ 71 = 604 225 / 604 000	(2)

Question Number	Answer	Additional Guidance	Mark
3(c)	answer in standard form	e.g. 0.5×10^7 / 5×10^6	(1)

Question Number	Answer	Additional Guidance	Mark
3(d)	An explanation that makes reference to the following: - because they want to validate their results (1) - by other members of the scientific community {checking / repeating / discussing / criticising} their work (1)	ACCEPT peer review to check . . .	(2)

Question Number	Answer	Additional Guidance	Mark
5(a)	The only correct answer is D A is incorrect because $(245\,000 - 49735) \div 245\,000 = 0.797$, $0.797 \times 100 = 79.7$ B is incorrect because $(245\,000 - 49735) \div 245\,000 = 0.797$, $0.797 \times 100 = 79.7$ C is incorrect because $(245\,000 - 49735) \div 245\,000 = 0.797$, $0.797 \times 100 = 79.7$		(1)

Question Number	Answer	Additional Guidance	Mark
5(b)(i)	The only correct answer is D A is incorrect because both have peptidoglycan in their cell wall (1) and a Gram negative bacteria has a thinner cell wall (3) <i>S. aureus</i> is gram positive so statement 2 is incorrect B is incorrect because both have peptidoglycan in their cell wall (1) and a Gram negative bacteria has a thinner cell wall (3) C is incorrect because both have peptidoglycan in their cell wall (1) and a Gram negative bacteria has a thinner cell wall (3) <i>S. aureus</i> is gram positive so statement 2 is incorrect		(1)

Question Number	Answer	Additional Guidance	Mark
5(b)(ii)	The only correct answer is A B is incorrect because <i>S aureus</i> releases exotoxins whilst it is alive C is incorrect because <i>S aureus</i> releases exotoxins whilst it is alive D is incorrect because <i>S aureus</i> releases exotoxins whilst it is alive		(1)

Question Number	Answer	Additional Guidance	Mark
5(c)	The only correct answer is A B is incorrect because a vaccine is artificial and the antigens contained stimulate an immune response C is incorrect because a vaccine is artificial and the antigens contained stimulate an immune response D is incorrect because a vaccine is artificial and the antigens contained stimulate an immune response		(1)

Question Number	Answer	Additional Guidance	Mark
5(d)(i)	An explanation that makes reference to three of the following: - few T helper cells at start as delay whilst antigen is being presented (1) - some T helper cells present as they have been activated and are beginning to divide (1) - large number of T helper cells by day 2 due to clonal expansion (1) - drop in number after 21 days as T helper cells have {died / moved out of the lymph nodes} (1)	IGNORE descriptions of the immune response not linked to time ACCEPT description of clonal selection linked to increase ACCEPT large number due division by mitosis	(3)

Question Number	Answer	Additional Guidance	Mark
5(d)(ii)	An explanation that makes reference to three of the following: • no antibodies in control mice as they had not been exposed to antigen before (1) • Rapid production of antibodies in vaccinated mice due to secondary immune response (1) • immediate increase in antibodies in vaccinated mice as they had memory cells present as a result of the vaccine (1) • therefore rapid increase in plasma cells to release antibodies (1)	Mouse must undergo primary immune response (which takes time) ACCEPT converse	(3)

Question Number	Answer	Additional Guidance	Mark
7(a)	The only correct answer is B <i>A is incorrect because Ebola is an RNA virus</i> <i>C is incorrect because Ebola is an RNA virus and is not a retrovirus</i> <i>D is incorrect because Ebola is not a retrovirus</i>		(1)
Question Number	Answer	Additional Guidance	Mark
7(b)	An explanation that makes reference to the following: - because they are non-living / have a protein coat (1) - therefore antibiotics have {no / few} (target) sites (1) OR - because they, reproduce / hide / go through latency, inside cells (1) - and therefore drugs cannot access them (1)	ACCEPT - high mutation rate / antigenic variability - therefore, antibodies no longer complementary (to antigens) / antiviral drugs no longer work	(2)
Question Number	Answer	Additional Guidance	Mark
7(c)(i)	An answer that makes reference to the following: - outbreaks do not occur every year / Ebola is rare (1) - number of cases of Ebola is (relatively) low except in <u>2014</u> (1)	ACCEPT (Ebola) doesn't occur often ACCEPT most cases occurred in <u>2014</u>	(2)
Question Number	Answer	Additional Guidance	Mark
7(c)(ii)	An answer that makes reference to the following: - not all infections documented / some asymptomatic infections (1) - some people died without a diagnosis / are not seen by a healthcare professional (1)	ACCEPT not diagnosed	(2)
Question Number	Answer	Additional Guidance	Mark
7(c)(iii)	2 : 1 (1)	$10\,141 : 4\,922 = 2.06034132 : 1$	(1)



Question Number	Indicative content	
*7(d)	Indicative content: P. Methods for reducing spread between people: - Isolation / quarantine - protective clothing - covering wounds - testing / increase testing facilities - train healthcare workers to recognise early symptoms (of Ebola) - not sharing needles - limit movement into uninfected areas and out of infected areas A. Methods for reducing spread between animals and people: - not eating meat of carrier animals - cooking meat thoroughly - covering uncooked meat - washing fruits and vegetables C. Climate change and land use: - monitoring conditions and advising / regulate land use - education about appropriate land use / promote sustainable agricultural practices - monitor wildlife for signs of disease E. Economy and health: - more money in health service - develop rapid response teams - education about better health and hygiene/ public awareness campaign - development of vaccines - use of vaccines - stockpile medical supplies / PPE D. Disadvantages: - lack of money / costly - trade-offs with other programmes - public resistance	Level 1 1 mark: answer has 1 comment from any aspects 2 marks : answer has 2 comments from any aspect Level 2 : 3 marks : answer has 3 comments from at least 2 aspects 4 marks : answer has 4 comments from at least 3 aspects Level 3 : 5 marks : answer has 5 comments from 4 aspects 6 marks : answer has comments from all 5 aspects
	- mistrust of authorities - misinformation - poor access to remote areas - limited healthcare workforce - dependent on foreign aid - impact on food supply	

Number	Answer	Additional Guidance	Mark
8a	An explanation that makes reference to the following: - unable to {replicate / reproduce} independently (1) - because they do not have appropriate {organelles / enzymes} (1)		(2)

Question Number	Indicative content	
*8bi	Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. - graph shows rapid rise between April and December 2014 in Sierra Leone - maps show rapid spread between April and December 2014 in all three countries - initial outbreak at border between Guinea, Sierra Leone and Liberia - more case in Guinea in March 2014 - greater increase in Sierra Leone compared with Liberia and Guinea - greater density of cases in Sierra Leone at high of outbreak - some areas of Guinea have {few/no } cases (even at height of outbreak) - spread in Sierra Leone has come from {Guinea / western districts of Sierra Leone} - in April 2014 month Ebola has spread further into Liberia - January 2015 graph shows slight decrease and so does one region in Sierra Leone - most rapid increase near capital cities - because of high population density - maps show significant variation in number of cases in different districts - graph shows rapid fall in Sierra Leone after January 2015 - no information provided whether there was also a fall in Guinea and Liberia after January 2015	
Level	Marks	
0	0	No awardable content
1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly one piece of scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.

2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.
3	5-6	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear, coherent and logically structured.

Additional Guidance

Level 1 response = either the graph or maps have been analysed with some relevant trends and patterns identified.

Level 2 response = data from both the graph and the maps are used and some links are made between the two sets of data

Level 3 response = detailed trends in both the graph and maps are compared and there is some consideration given to the evaluation of the data e.g. what data is missing for relevant conclusions to be reached.

Question Number	Answer	Additional Guidance	Mark
8bii	A description that makes reference to three of the following: - rapid {identification of disease / diagnosis} (1) - methods used to prevent transmission described (1) - identify who may have been in contact with the infected individual and isolate them (1) - education program for burial of corpses (1)	Accept: hygiene / barrier methods of contraception / isolate infected individuals / sterilisation or disposal of equipment, bedding or clothes / wear protective clothing / increased border security	(3)



Question Number	Answer	Additional Guidance	Mark
8c	An answer that makes reference to four of the following, including a conclusion: reasons for – • Ebola has high mortality (1) • new drug is unlikely to affect other people (1) • may help develop the drug for other patients (1) reasons against – • unknown side effects (1) • patient may not be able to provide informed consent (1) • who decides who can be treated if the drug is in limited supply (1) • conclusion reached (1)	epidemic may be difficult to control e.g. benefits may outweigh the risks due to the severity of the Ebola outbreak	(4)
Question	Answer	Additional Guidance	Mark

Question Number	Answer	Mark
1(a)	1(a). The only correct answer is A <i>B is not correct because there are 5 monocytes and 8 neutrophils</i> <i>C is not correct because there are 3 lymphocytes, 5 monocytes and 8 neutrophils</i> <i>D is not correct because there are 3 lymphocytes</i>	(1)

Question Number	Answer	Mark
1(b)	1(b). The only correct answer is C <i>A is not correct because erythrocytes transport oxygen and platelets prevent entry of bacteria</i> <i>B is not correct because erythrocytes transport oxygen and platelets prevent entry of bacteria</i> <i>D is not correct because leucocytes are involved in defence</i>	(1)

Question Number	Answer	Additional Guidance	Mark
1(c)	An explanation that makes reference to two of the following: (bone marrow / body / patient / person) produces more cells / more released into blood (1) - because patient has {an allergy / allergic inflammation} (1) - because patient has a parasitic infection e.g. worms (1)	Accept any two from : asthma /tropical pulmonary eosinophilia / Loeffler syndrome / Churg-Strauss syndrome / atopic dermatitis / eosinophilic oesophagitis / hypereosinophilic syndromes / some malignancies / adverse drug reactions / allergic rhinitis / atopic asthma / atopic dermatitis	(2)

Total for Question 1 = 4 MARKS



Question Number	Answer	Additional Guidance	Mark
5(b)	An explanation that makes reference to two of the following: - because it results in herd immunity (1) - therefore there will be fewer infected people to pass virus onto uninfected people (1) - protect people who cannot become immune (1)	ACCEPT large number of people immunised reduces the chance of someone not immune getting infected e.g. allergic to vaccines, immunodeficient, immunosuppressed, HIV	(2)

Question Number	Answer	Additional Guidance	Mark
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Question Number	Answer	Additional Guidance	Mark
5(a)	The only correct answer is B A is incorrect because injection of antibodies is passive C is incorrect because injection of antibodies is artificial and passive D is incorrect because injection is artificial		(1)

Question Number	Answer	Additional Guidance	Mark
5(b)(i)	6×10^3 / 6.0×10^3 / 6 000 (1)		(1)

Question Number	Answer	Additional Guidance	Mark
5(b)(ii)	An answer that makes reference to three of the following: - time taken to agglutinate decreases with increase in antibody concentration (1) - credit comment about lack of error bars (in graph 1) (1) - antibody {reduces / prevents} sperm from escaping (1) - concentration of antibody does not affect the percentage of sperm escaping (1) - credit comment about overlapping error bars (in graph 2) (1)	IGNORE attempts to explain data ACCEPT inverse (proportional) relationship (weak) negative correlation ACCEPT significant / valid IGNORE reliable / accurate / precise ACCEPT significant / valid IGNORE reliable / accurate / precise	(3)

Question Number	Answer	Additional Guidance	Mark
5(b)(iii)	An explanation that makes reference to three of the following: - because antibodies have (more than one identical) binding sites (1) - antibodies are specific to (one) antigen (1) (bind head and flagellum) there may be the same {antigen / antibody-binding site} on both the head and the flagellum (1) (only bind head or flagellum) there may be different {antigen / antibody-binding site} on the head and the flagellum (1) - because there may be (three) different types of antibody present (in the contraceptive) (1)	NB careful with the term 'variable region' as it is used for the antigen-binding site ACCEPT on all parts of cell tail to mean flagellum	(3)

Question Number	Answer	Additional Guidance	Mark
5(c)	An explanation that makes reference to the following: - because at low concentrations the collision between antibody and {antigen / sperm} {will take longer / are less frequent} (1) - because at high concentrations there may be insufficient antibodies (1)	ACCEPT chances of attaching are lower ACCEPT lower antibody : sperm IGNORE too many sperm cells unless qualified with a comment relating to antibody limiting factor unless qualified	(2)

Question Number	Answer	Additional Guidance	Mark
6(a)	A description that makes reference to the following: - antigen on {surface / membrane} of macrophage (1) - binding of antigen to {CD4 / receptor} on T helper cell (1)	ACCEPT antigen on MHC on macrophage	(2)

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	An explanation that makes reference to the following: - to prevent DNA {replication / unwinding / unzipping} (1) - so that macrophages could not {divide / carry out mitosis} (1) - so that any division could be attributed to the T cells only / radioactive thymidine incorporated into T cells only (1)	ACCEPT separating ACCEPT number of macrophages remains constant ACCEPT no thymidine incorporated into the macrophage	(3)

Question Number	Answer	Additional Guidance	Mark
6(b)(ii)	An explanation that makes reference to two of the following: {complementary to / binds to / forms H bonds with} adenine (on the DNA) (1) - forming phosphodiester bonds (with adjacent nucleotides) (1)	ACCEPT formation of a sugar-phosphate backbone	(2)

Question Number	Answer	Additional Guidance	Mark
6(b)(iii)	An explanation that makes reference to four of the following: - most (radioactive) thymidine incorporated into T cells that were the same strain as the macrophages (1) - because these cells are dividing more (1) - because {the (MHC and CD4) receptors bind together better / antigen presentation improved} (1) - due to genetic compatibility (1) - strain 2 {macrophages are better antigen presenters / T cell proliferate faster than strain 13} (1)	ACCEPT converse throughout ACCEPT more T cells if antigen is presented by macrophages from same {strain / number} guinea pig description ACCEPT faster mitosis ACCEPT better recognition ACCEPT self-antigens ACCEPT antigen presentation is more effective	(4)

Question Number	Answer	Additional Guidance	Mark
6(a)	An explanation that makes reference to two of the following: - MHC needed if endothelial cells were to {present antigen / be antigen presenting cells} (1) - antigen binds to MHC molecules (1) - MHC-antigen complex involved in activation of T helper cells (1)	ACCEPT antigens presented on MHC ACCEPT MHC-antigen complex binds to (CD4) receptor on T helper cells	

Question Number	Answer	Additional Guidance	Mark
6(b)	An explanation that makes reference to two of the following: - because stops DNA replication in endothelial cells (1) - dividing cells {take up / use} the (radioactive) thymidine (1) - so that any radioactive thymidine uptake will be by the T cells (only) (1)	N.B. 'They' or 'cells' refers to the endothelial cells ACCEPT DNA synthesis uses thymidine ACCEPT only T cell division can be measured	

Question Number	Answer	Additional Guidance	Mark
6(c)	An explanation that makes reference to the following: - to remove any thymidine (not taken up) (1) - which would result in an over estimate of the {number of T cells / thymidine present} (1)	ACCEPT {inaccurate / not valid} result for the T cells	

Question Number	Answer	Additional Guidance	Mark
6(d)(i)	An explanation that makes reference to the following: - to determine any passive uptake of radioactive thymidine / to see if T cells take up thymidine without antigen present (1) - to show that antigen is stimulating the T cells (to divide) (1)	ACCEPT to compare the thymidine with and without antigen ACCEPT to see the effect of antigen (on T cells)	

Question Number	Answer	Additional Guidance	Mark
6(d)(ii)	An explanation that makes reference to three of the following: - endothelial cells are best at presenting Con A (and MBP) / Con A (and MBP) are presented (1) - endothelial cells are least effective at presenting OVA (and PPD) / OVA (and PPD) are not presented (1) - because there is very little difference between antigen and {no antigen / control} (1) - because {error bars for Con A and MBP are not overlapping / error bars for OVA and PPD are overlapping} with the control (1)	N.B. Con A (and MBP) have the highest level of thymidine and OVA (and PPD) the least = 1 mark if no other marks awarded	

	Additional Guidance	Mark	Answer	Mark
placebo} / GM plant cell} (1)	ACCEPT range of vaccine concentration if one is zero	(5)	are following: ylic acid / COOH / carboxyl group} (1) {a double bond / C=C / carbons with only one H} (1)	(2)
	ACCEPT (infection with virus and) {observe symptoms / ill / diseased / survive} DO NOT ACCEPT group			
			Answer	Mark
			ir of the following: ene / DNA / allele / plasmid} (1) 'DNA / allele} (1)	
			ne gun / virus / electroporation /	
			ACCEPT remove cell wall / produce a protoplast	(2)

Question Number	Answer	Additional Guidance	Mark
8(a)	A description that makes reference to four of the following: - mRNA used (by macrophage in translation) to synthesise {(poly)peptide / protein / antigen / amino acid} (1) - polypeptide {transported in RER / modified in Golgi / packaged in Golgi} (1) {antigen / protein} expressed on (macrophage) {surface of cell / membrane} (1) - antigen attached to MHC (molecule) (1) - binding of macrophage to T helper cells (1)	IGNORE ref to {viral antigens / reverse transcription} for mp 3, 4 and 5 ACCEPT mRNA is translated / translation of mRNA DO NOT ACCEPT transcription DO NOT ACCEPT mRNA attaches IGNORE antigen moved towards membrane unless qualified that this is for presentation ACCEPT macrophage binds to CD4 (antigen on T helper cells)	(4)

Question Number	Answer	Additional Guidance	Mark
8(b)	An answer that makes reference to four of the following: Similarities: - both are active forms of immunity (1) - both involve T helper cells (1) - both involve cytokines (1) - both result in the production of memory cells (1) Differences - antigen presentation in HIR is by {B cells (themselves) / antibody bound to B cells} AND in CMI the infected host cells present the antigen (1) {B cells / plasma cells} involved in the HIR but not in the C-MIR OR T killer cells involved in the C-MIR but not in the HIR (1) - antibodies involved in HIR AND {not in the C-MIR / enzymes in C-MIR} (1) - HIR involved in (cell-free) {antigens / pathogens} (and infected host cells and cancer cells) AND C-MIR involved with host-infected cells (1)	NB do not piece together except two adjacent sentences making single comparative point or comparative points linked between two sentences At least one similarity and one difference for full marks. DO NOT ACCEPT cytokinins IGNORE types of memory cells, even if muddled up IGNORE macrophages present antigen if mentioned in both but DO NOT ACCEPT if only mentioned in one ACCEPT T cytotoxic cells ACCEPT {B cells / plasma cells} involved in the HIR but T killer cells involved in the C-MIR IGNORE T helper cells if mentioned in both but DO NOT ACCEPT if only mentioned in one ACCEPT perforin	(4)

Question Number	Answer	Additional Guidance	Mark
8(c)	An explanation that makes reference to the following: {chemicals / enzymes / perforins} (from T killer cells / CMI) will cause destruction of cancer cells (1) - antibodies (from HI) will bind to the cancer cells / opsonisation of cancer cells (by antibodies) (1) - therefore macrophages will engulf the cancer cells (as a result of the HIR) (1) - and {enzymes break down the cancer cells / cancer cells are digested} (by phagocytes) (1)	ACCEPT in context of either primary or secondary immune response IGNORE T killer cells bind to cancer cells IGNORE agglutination B cells produce antibodies refs to pathogens DO NOT ACCEPT antibodies destroy cancer cells ACCEPT neutrophils / phagocytes	(4)

Question Number	Answer	Additional Guidance	Mark
5(a)	The only correct answer is A B is incorrect because TS is monosomy not polysomy C is incorrect because TS is non-disjunction not translocation D is incorrect because TS is non-disjunction not translocation		(1)

Question Number	Answer	Additional Guidance	Mark
5(b)	- number of baby girls born calculated (1) (number of baby girls with TS) calculated (1)	$(613\,936 \div 2.05 =) 299\,481/299480.976$ $299\,481 \div 2500 = 119.7924$ 119/120 Correct answer 119/120 gains full marks	(2)

Question Number	Answer	Additional Guidance	Mark
5(c)(i)	An explanation that makes reference to the following: - because the vaccine will stimulate a (primary) immune response (1) - so there will be a higher number of {lymphocytes / antibodies} (1) - giving false-positive results (1)	Accept they will have memory cells Do Not accept a change in lymphocyte/antibody levels Accept {making the study/results of the study invalid/results skewed}	(3)

Question Number	Answer	Additional Guidance	Mark
5(c)(ii)	An explanation that makes reference to the following: - standardised height score (1) - because {the standard deviation values do not overlap/ the error bars do not overlap with the other group} (1)	Accept smallest value for group w/o TS is -0.91 and largest value with TS is -1.21	(2)

Question Number	Answer	Additional Guidance	Mark
5(c)(iii)	An answer that makes reference to the following: - girls with TS have lower levels of IgG/IgA (1) - girls with TS have fewer CD4 cells but {the same / more} CD8 cells (1) - No significant difference (in the levels of antibodies and lymphocytes)/ error bars overlap (1)	Do not piece together Accept: Apart from CD8 lymphocytes all the other markers are lower in girls with TS = 2 marks	(2)

Question Number	Answer	Additional Guidance	Mark
5(c)(iv)	An explanation that makes reference to two of the following: - Girls from both groups (from the study) divided into those with autoimmune disease and those without (1) - So that one group has TS and autoimmune disease/one group has TS and no autoimmune disease (1) - so that the numbers of T regulatory cells could be compared (1)		(2)

Question Number	Answer	Additional Guidance	Mark
7(a)(i)	The only correct answer is D A is incorrect because antibodies have two antigen binding sites B is incorrect because the two binding sites attach to the antigen and not the macrophage C is incorrect because there is only one macrophage binding site		(1)

Question Number	Answer	Additional Guidance	Mark
7(a)(ii)	The only correct answer is B A is incorrect because hydrolysis reactions breakdown molecules C is incorrect because nucleotides are the monomers of polynucleotides not proteins D is incorrect because nucleotides are the monomers of polynucleotides not proteins		(1)

Question Number	Answer	Additional Guidance	Mark
7(a)(iii)	An explanation that makes reference to the following: • (because water enters part of cell) by osmosis (1) • from a high water potential to a low water potential / because the osmotic potential inside the cell is lower / from a low solute concentration to a higher solute concentration (1)	ACCEPT more concentrated cytoplasm solute potential for osmotic potential	(2)

Question Number	Answer	Additional Guidance	Mark
7(a)(iv)	A description that makes reference to three of the following: • bacteria engulfed and {digested / broken down} (1) • antigen attached to MHC antigen (1) • macrophage becomes an antigen-presenting cell (to the T helper cell) (1) • CD4 (antigen) of T (helper) cell binds to {antigen / macrophage} (1)	ACCEPT macrophage presents the antigen (to the T helper cell) NB CD4 (antigen) of T (helper) cell binds to {antigen-MHC complex = 2 marks	(3)

Question Number	Indicative content		Mark
*7(b)	Indicative content: Graph 1 (concentration of bacteria) • as time increases the number of bacteria taken up increases • the more microorganisms present the more enhanced the uptake is • but this is not proportional to number present • effect only seen after 10 minutes Graph 2 (number of macrophages) • the more macrophages present the more uptake of bacteria • but this difference is only marked with 100 000 macrophages present • effect only seen after 30 minutes Graph 3 (source of macrophages) • source of macrophages affects how many bacteria are taken up • bone marrow cells take up more of both types of bacteria • type of bacteria affects how many bacteria are taken up • combination of both affects uptake Graph 4 (concentration of ATP synthase inhibitor) • presence of ATP synthase inhibitor reduces uptake of bacteria • as there is no ATP available for phagocytosis • but differences only really seen are concentrations of 100 a.u. and above	Level 1: 1 mark = 1 comment on one set of data 2 marks = two sets of data commented on Level 2: Comments must relate to phagocytosis ie not just a description of green glow 3 marks = three sets of data commented on 4 marks = four sets of data commented on Level 3: 5 marks = four sets of data commented on, with an extended comment on one set 6 marks = four sets of data commented on, with an extended comment on at least two sets of data	6



Number	Answer	Additional Guidance	Mark
7(a)(i)	An explanation that makes reference to the following: - to {kill / attenuate / inactivate / weaken / prevent reproduction} (1) - therefore less risk of {infection / disease / malaria} (1)		(2)

Question Number	Answer	Additional Guidance	Mark
7(a)(ii)	vaccinate with {no <i>Plasmodium</i> / saline / water}	ACCEPT placebo	(1)

Question Number	Answer	Additional Guidance	Mark
7(a)(iii)	An explanation that makes reference to three of the following: - effective for {group B / high dose} because zero infected / not effective for {group A / low dose} as some infected (1) - sample size of {group B / high dose} was {small / only 6 people} / sample sizes were small (1) {group A / low dose} result similar to the {control / group C} (1) (sample selection unknown so) no information about {gender / age / culture / health / prior infection} (1)	ACCEPT 100% effective for group B	(3)

Question Number	Answer	Additional Guidance	Mark
7(a)(iv)	A description that makes reference to five of the following: - antigen presenting cells / MHCs (1) - APC binds to {T cell / CD4 receptors} (1) - production of T memory cells (1) (activated) T cells {stimulate B cells / release cytokines} (1) - production of B memory cells (1) - plasma cells release antibodies (1)		(5)

Question Number	Answer	Additional Guidance	Mark
7(b)	An explanation that makes reference to three of the following: {random / chance} mutations (1) - produce {proteins / enzymes} that make the drug ineffective (1) - therefore resistant organisms pass on allele (1) - drug is the selection pressure (1)	DO NOT ACCEPT if mutation caused by drug DO NOT ACCEPT pass on mutation / gene	(3)

Question Number	Answer	Mark
9(a)	9(a). The only correct answer is D <i>A is not correct because macrophages do not produce antibody</i> <i>B is not correct because memory cells do not produce antibody</i> <i>C is not correct because neutrophils do not produce antibody</i>	(1)

Question Number	Answer	Additional Guidance	Mark
9(b)	A description that makes reference to the following: - changes that affect gene {expression / activation} (1) - credit an example of epigenetic modification (1) - involved in {differentiation / change in function / change in proteins synthesised } (1)	Do not accept altering the DNA / base sequence / genetic code e.g. DNA methylation, histone {modification / methylation / acetylation} / chromatin remodelling / non-coding RNA / transcription factors Accept when a B cell becomes a plasma cell	(3)

Question Number	Answer	Additional Guidance	Mark
9(c)	An explanation that makes reference to two of the following: - to produce lots of {genetically identical / hybridoma} cells (1) - so that lots of antibodies (of one type) can be produced (by hybridoma cells) (1) - so that the hybridoma cells can divide (1)	Accept because a {fully-differentiated / antibody-producing / plasma} cell cannot divide	(2)

Question Number	Answer	Additional Guidance	Mark
9(d)(i)	An explanation that makes reference to the following: - humanised antibodies will not trigger an immune response / mouse antibodies could trigger an immune response (1) - antibodies would {bind to cancer cells so that macrophages could destroy the cancer cells / opsonise the cancer cells} (1) - the antibodies are target specific (1) - reducing the need for other {treatments / named treatment} (1)	Accept humanised antibodies will not be recognised as {foreign / as an antigen} / mouse antibodies could be recognised as {foreign / as an antigen} Accept antibodies will bind only to cancer cells Accept have less {side effects / named side effects}	(3)

Question Number	Indicative content
*9(d)(ii)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Description: - mouse antibody is made of all mouse components - humanised antibody consists mostly of human components - mouse antibody recognised by the patient's immune system (rejection) - mouse protein acts as an antigen Consequence: - mouse antibody could be destroyed - mouse antibodies would not persist in the body - macrophages may not bind to mouse antibody - so phagocytosis of the cancer cells would not be enhanced - humoral / B cell immune response could be initiated - macrophages may phagocytose the mouse antibody Immunology: - details of how macrophage destroys antibody - macrophage becomes an antigen-presenting cell - T helper cells become activated - antibodies against the mouse antibodies could be produced (by plasma cells) Accept converse for humanised antibody throughout

Level 0	0	No awardable content
Level 1	1-2	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context. Description of mouse antibody resulting in rejection (Accept converse for humanised antibody throughout)
Level 2	3-4	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts to provide the explanation being presented. Lines of argument occasionally supported through the application of relevant evidence (scientific ideas, processes, techniques and procedures). The explanation shows some linkages and lines of reasoning with some structure. Details given on why the mouse antibodies may not be effective in treating the cancer (Accept converse for humanised antibody throughout)
Level 3	5-6	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts to provide the explanation being presented. Line(s) of argument supported throughout by sustained application of relevant evidence (scientific ideas, processes, techniques and procedures). The explanation shows a well-developed and sustained line of reasoning which is clear, coherent and logically structured. Explanation of how the mouse antibody could be destroyed by the immune system (Accept converse for humanised antibody throughout)

Total for Question 9 = 15 MARKS

TOTAL FOR PAPER = 90 MARKS



Question Number	Answer	Additional Guidance	Mark
8(a)	An answer that makes reference to the following: Similarities - both contain DNA (1) Differences - HPV is surrounded by {protein / capsid} and chlamydia by {a cell wall / peptidoglycan} (1) - HPV is hollow and chlamydia has {cell membrane / cytoplasm / ribosomes / glycogen granules / lipid droplets / plasmids} (1)	ACCEPT DNA strands in HPV ACCEPT chlamydia has {cell membrane / cytoplasm / ribosomes / glycogen granules / lipid droplets / plasmids} but HPV does not	(3)

Question Number	Answer	Additional Guidance	Mark
8(b)(i)	An explanation that makes reference to the following: - vaccine contains the HPV antigens (1) - which stimulates the production of memory cells (1) - therefore (secondary) immune response destroys HPV before it causes cancer (1)	ACCEPT {attenuated / inactive / harmless / fragments of} {virus / pathogen} DO NOT ACCEPT contains dead virus ACCEPT a description e.g. antibodies released faster so macrophages destroy HPV before it damages cells DO NOT ACCEPT antibodies destroy virus virus is killed	(3)

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	An explanation that makes reference to the following: - because the immune response is specific (1) - so on infection with Chlamydia there will not be memory cells present (specific to Chlamydia) (1) - and another (primary) immune response will need to be initiated (1) - therefore the Chlamydia will not be destroyed before it causes disease (1)	ACCEPT Chlamydia has different antigen to {HPV / the virus / the vaccine} ACCEPT no antibodies (against Chlamydia) present	(3)

Question Number	Indicative content	
*8(b)(iii)	Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Indicative content: Advantages of vaccinating girls and boys - protects students from becoming infected - virus less likely to get passed on - as there will be no virus to pass on during intercourse - because the virus will be destroyed before infections caused - the more girls vaccinated the fewer cases of cervical cancer and other conditions caused by HPV in girls - the more boys vaccinated the fewer cases of other conditions caused by HPV in boys because of {memory cells / active immunity} Advantages of vaccination in schools - more {boys / girls} likely to be vaccinated - because they are not reliant on a doctor's appointment being {made / available} - do not have to miss school for the appointment - seeing others being vaccinated might encourage others to get vaccinated - inoculating school children is likely to be before they become sexually active Points that can apply in either context (but only creditable once) - greater chance of developing herd immunity - therefore fewer infected people to pass virus onto uninfected people - help to protect those who cannot be infected	Level 1 1 mark = 1 comment 2 marks = 3 comments Level 2 : 3 marks = 4 comments 4 marks = 5 comments Level 3 NB must include points on advantages of vaccinating boys AND vaccinating in school 5 marks = 5 comments 6 marks = 6 comments

Number	Answer	Additional Guidance	Mark
2ai	D		(1)

Question Number	Answer	Additional Guidance	Mark
2aii	D Z-Y		(1)

Question Number	Answer	Additional Guidance	Mark
2bi	An explanation that makes reference to the following: - Gram positive bacteria have a thick layer of peptidoglycan in their cell wall (1) - some antibiotics inhibit (enzymes involved in) the formation of peptidoglycan so are effective against Gram positive bacteria (1) - some antibiotics are not able to cross the peptidoglycan layer so they are {more / only} effective against Gram negative bacteria (1)	accept converse, accept reference to teichoic acid	(3)

Question Number	Answer	Additional Guidance	Mark
2bii	An explanation that makes reference to the following: - because viruses are not living cells (1) - because viruses do not have a cell wall (1)	accept antibiotics usually target {cell walls / cell membranes / replication / translation / metabolism }	(2)

Question	Answer	Additional Guidance	Mark
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Question Number	Answer	Mark
1(a)(i)	The only correct answer is B doctors only prescribing antibiotics that are effective against the pathogen A is not correct because antibiotics being given to farm animals to prevent disease would increase numbers of resistant bacteria C is not correct because doctors only prescribing antibiotics for viral infections may increase numbers of resistant bacteria D is not correct because patients stopping taking the antibiotics when they feel better would increase numbers of resistant bacteria	(1)

Question Number	Answer	Mark
1(a)(ii)	The only correct answer is D the resistant bacteria surviving the antibiotic A is not correct because competition between bacteria is reduced B is not correct because the antibiotic does not reduce the frequency of mutation in the bacteria C is not correct because the resistant bacteria is not killed by the antibiotic	(1)

Question Number	Answer	additional guidance	Mark
1(b)(i)	An explanation that includes two of the following points: - more sterile precautions / example of in hospital / screen patients before admission (1) - so less disease transmitted / spread (1) - infection can be identified / spotted by medical staff / patient isolated (1)	Accept converse for community	(2)

Question Number	Answer	Mark
1(b)(ii)	An explanation that includes two of the following points: - community cases fall more / continue to fall and hospital cases level off(1) - because most precautions in hospital already taken / staff aware of precautions (1) - because in community more precautions are now being taken (1)	(2)

Question Number	Answer	additional guidance	Mark
1(c)	An explanation that includes the following points: - because DNA mapping of bacteria can identify resistance / genes that confer resistance (1) - so (only) targeted / effective / specific antibiotic for that bacterium are prescribed (1)	DNA mapping of bacteria can elucidate genes that show membrane / binding sites for antibiotics. Allow converse for use non-specific antibiotic	(2)

(Total for Question 1 = 8 marks)

Question Number	Answer	Additional Guidance	Mark
7(a)(i)	The only correct answer is B <i>A is incorrect because tetracycline targets the ribosomes</i> <i>C is incorrect because tetracycline targets the ribosomes and penicillin targets the cell wall</i> <i>D is incorrect because penicillin targets the cell wall</i>		(1)

Question Number	Answer	Additional Guidance	Mark
7(a)(ii)	The only correct answer is B <i>A is incorrect because tetracycline is bacteriostatic</i> <i>C is incorrect because tetracycline is bacteriostatic and penicillin is bactericidal</i> <i>D is incorrect because penicillin is bactericidal</i>		(1)

Question Number	Answer	Additional Guidance	Mark
7(b)	An explanation that makes reference to the following: - antibiotics are only prescribed if the illness could be caused by bacteria / antibiotics not prescribed if the illness is caused by viruses only (1) - because antibiotics acts as a selection pressure for resistant bacteria (1)	ACCEPT reduces the {use of antibiotics / exposure of bacteria to antibiotics} ACCEPT a description e.g. presence of antibiotic wont be a selective advantage DO NOT ACCEPT immune	(2)

Question Number	Answer	Additional Guidance	Mark
7(c)(i)	- number of chicken and cattle with resistant <i>E.coli</i> (1) - ratio given (1) OR - mean percentage of resistant bacteria in chickens calculated (1) - ratio given (1)	Example of calculation: $(43 + 25) / 68$ chickens and 3 cattle $22.67 : 1 / 22.7 : 1 / 23 : 1 / 1 : 0.04$ $(95.86 + 55.56) \div 2 = 75.71$ $(75.71 : 25.00) = 3.03 : 1 / 3 : 1$ ACCEPT $1 : 0.33 / 1 : 0.3 / 1 : 1$ NB correct answer with no working gains two marks $\{6.06 : 1 / 6.1 : 1 / 6 : 1 / 1 : 0.17 / 1 : 0.2\} = 1$ mark	(2)

Question Number	Answer	Additional Guidance	Mark
7(c)(ii)	- mean number of resistant bacteria for cattle or rodents calculated (1) - answer (1)	Example of calculation: $8.33\% \text{ of } 2 \times 10^8 = 16.66 \times 10^6$ OR $14.58\% \text{ of } 6 \times 10^9 = 87.48 \times 10^7$ $53 / 52.5 / 52.51$ (times more) $8.6 \times 10^8 / 8.58 \times 10^8 / 858$ 140 000 etc (more bacteria) correct answer with no working gains two marks	(2)

Question Number	Answer	Additional Guidance	Mark
7(c)(iii)	An answer that makes reference to four of the following: • (idea supported because) overall there are more resistant bacteria in the animals reared for food (1) • (idea not entirely supported because) the bacteria in wild animals are more resistant to cephalothin (1) • the number of animals in each group is very small (1) • the number of different types of {animal / antibiotic} is limited (so data may not be representative) (1) • no standard deviations shown so spread of data is unknown (1)	ACCEPT other quoted data to illustrate exception ACCEPT validity of data	(4)

Number	Answer	Additional Guidance	Mark
8(a)	An answer that makes reference to six of the following: • make extract of pineapple juice (1) • same {volume of skimmed milk / volume of pineapple juice extract} (1) • {use colorimeter to measure changes in absorbance with time / beaker over a black cross and time to disappear} (1) • calculation of initial rate (1) • at a range of temperatures using a water bath (1) • pH controlled using buffer (1) • plot graph of initial rate against temperature (1)	Allow other appropriate methods Allow use colorimeter to measure transmission Allow measure absorbance every 30s Allow 10 – 80°C (must be at least 5 temps)	(6)

Question Number	Answer	Additional Guidance	Mark
8 (b)(i)	An answer that makes reference to two of the following: • Gram positive bacteria have more peptidoglycan than Gram negative bacteria (1) • Gram positive stains {purple / blue} (with Gram stain), but Gram negative do not stain {purple / blue} (with Gram stain) (1) • Gram positive contains {teichoic acid / lots of murein} but Gram negative do not (1) • Gram positive have no {periplasmic space / outer membrane} but Gram negative do (1)	Allow Gram positive have a thicker cell wall than Gram negative Allow Gram positive stains {purple / blue} (with Gram stain), but Gram negative stain red (with Gram stain) Allow Gram positive have low {lipid / phospholipid} content but Gram negative have high {lipid / phospholipid} content	(2)

Question Number	Answer	Additional Guidance	Mark
8 (b)(ii)	An answer that makes reference to the following: • conversion of micrometres to mm (1) • calculation of speed (1)	Example calculation $1\mu\text{m} = 0.001\text{ mm}$ $0.001 \times 100 = 0.1\text{ (mm s}^{-1}\text{)}$ Correct answer with no working gains full marks	(2)

Question Number	Answer	Additional Guidance	Mark
8(b)(iii)	An explanation that makes reference to two of the following: • BvB can kill gram negative bacteria (1) • without side effects for humans (1) • therefore could be useful when treating resistant bacterial infections (1)	Allow bacteria cannot become resistant to BvB	(2)

Number	Answer	Additional Guidance	Mark
7(a)	An answer that includes six of the following: - suitable method of making root extract (1) - method of controlling concentration (1) - suitable method of growing bacteria (1) - suitable method of applying extract (1) - carried out with and without turmeric (1) - suitable {time / temp} for incubation (1) - method of collecting results (1) - use of suitable stats test to test hypothesis (1) - description of aseptic technique (1)	eg grind / liquidise with sterile water and filter eg known mass in known volume of water eg on agar plates or in broth / liquid growth medium eg on filter paper discs / in wells in agar or as liquid to nutrient broth / accept turmeric in agar accept compared with water / solvent used Ignore different concentrations as long as one is 0 Accept 24-72 hours / temperature at or below 30°C eg diameter / area of clear area on agar eg liquid method eg haemocytometer / turbidity in colorimeter Accept counting colonies if turmeric in agar eg t-test Accept use of replicates to calculate SD	(6)

Question Number	Answer	Additional Guidance	Mark
7(b)	An answer that includes a maximum of four of the following: - small number of patients in trial (1) - short duration of trial (1) - limited range of ages involved in trial (1) - not a double-blind study (1) - measurement of pain is subjective (1) and up to four of the following: - relevant comment on pain reduction (1) - relevant comment on side effects (1) - relevant comment on overall outcome (rated by doctors) (1) - relevant comment on weight loss (1)	Accept people with complex conditions excluded Accept patients knew which treatment they were getting / patients may have been biased eg very little difference between treatments eg curcumin had fewer side effects eg very little difference between treatments eg curcumin causes weight loss eg weight loss will improve symptoms / not good if person already underweight	(6)

(Total for Question 7 = 12 marks)



Number	Answer	Additional Guidance	Mark
10(a)(i)	benzylpenicillin		(1)

Question Number	Answer	Additional Guidance	Mark
10(a)(ii)	An answer that makes reference to one of the following: - human cells are {eukaryotic / lack cell wall / lack peptidoglycan} (1) - human cells have different {ribosomes / enzymes} (1)	ACCEPT these antibiotics only affect prokaryotes	(1)

Question Number	Answer	Additional Guidance	Mark
10(b)	An explanation that makes reference to the following: {binds to / changes shape of} the {enzyme / active site / RNA polymerase} (1) - therefore {transcription / mRNA synthesis} prevented (1) - no {proteins / polypeptides / enzymes} can be made (1)		(3)

Question Number	Answer	Additional Guidance	Mark
10(c)(i)	- multiplication (1) - division (1)	2×10^{10} divisions per day $\times 10^{-7}$ mutations per division / $2 \times 10^{10} = 20\,000\,000\,000$ $\div 10\,000\,000 / = 2\,000 / 2 \times 10^3$ Correct answer gains full marks, with no working shown ALLOW one mark for $20\,000\,000\,000 / \div 10\,000\,000 / 10 \times 10^6 / 1 \times 10^7$	(2)

Question Number	Answer	Additional Guidance	Mark
10(c)(ii)	An explanation that makes reference to three of the following: - different {R groups / disulphide bonds / hydrogen bonds / ionic bonds} (1) - therefore different secondary / tertiary structure (1) - therefore different shaped ribosome (1) - therefore streptomycin cannot bind (to ribosome) (1)		(3)

Question Number	Answer	Additional Guidance	Mark
10(d)	An answer that makes reference to five of the following points: - same species of bacteria (1) - same {concentration / volume} of antibiotic (1) - use {agar / broth / culture medium} (1) - incubate between 20°C and 25°C for stated time (1) - measure {zone of inhibition / turbidity} (1) - use of described aseptic technique (1)	DO NOT ACCEPT less than 24 hours e.g. use of Bunsen burner / flame loop / swab bench	(5)