

PEARSON EDEXCEL A-LEVEL BIOLOGY A • 9BN0

BIOLOGY



EXAM QUESTION PACK

TOPIC 6: IMMUNITY, INFECTION AND FORENSICS

SCORE

/632

PERCENTAGE

%

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Q1.

Histamine and the proteins interferon and lysozyme are involved in the non-specific responses to infection.

(a) (i) Describe how the production and action of interferon differs from the production and action of lysozyme.

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(ii) Suggest why the protein structure of lysozyme is important to the way in which it acts against pathogens.

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(b) Following a bite by an insect, the area around the bite may show signs of inflammation as histamine is released.

(i) Explain why an insect bite, which breaks the surface of the skin, may lead to inflammation

around the injury.

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(ii) In order to reduce inflammation, a cream containing antihistamines might be applied to the skin, around an insect bite.

Suggest why applying this cream might be better than taking tablets containing antihistamines.

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(Total for question = 13 marks)

Q2.

The polar bear, *Ursus maritimus*, preys on seals and fish. Polar bears are adapted to live in cold Arctic regions.



Polar bear
Magnification $\times 0.04$

A recent study has shown that all polar bears are descended from populations that diverged from the Irish brown bear, *Ursus arctos*, approximately 120 000 years ago.

In this study, DNA from modern polar bears, the remains of historic polar bears and the remains of Irish brown bears was analysed.

(a) The first part of the study involved the amplification of DNA to give large enough samples for analysis.

(i) Describe how small samples of DNA can be amplified.

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(ii) Name **one** technique that could be used to analyse the amplified DNA samples.

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(b) Suggest how the scientists who conducted the study had their results accepted by other

scientists.

(2)

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(c) Suggest how each of the following may have contributed towards the divergence of polar bears and Irish brown bears into two separate species.

(i) Separation of the Arctic and Irish regions by sea

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(ii) Genetic mutation

(2)

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(Total for question = 11 marks)

Q3.

Peat bogs are formed over millions of years from the remains of plants and animals.

Waterlogging and acidic conditions prevent the decomposition of plants and animals in peat bogs.

The photograph shows peat being cut from a peat bog.



(Source: © Reimar/Shutterstock)

(i) State how the age of the layers in a peat bog can be determined.

(1)

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(ii) Explain why the conditions in peat bogs prevent decomposition.

(3)

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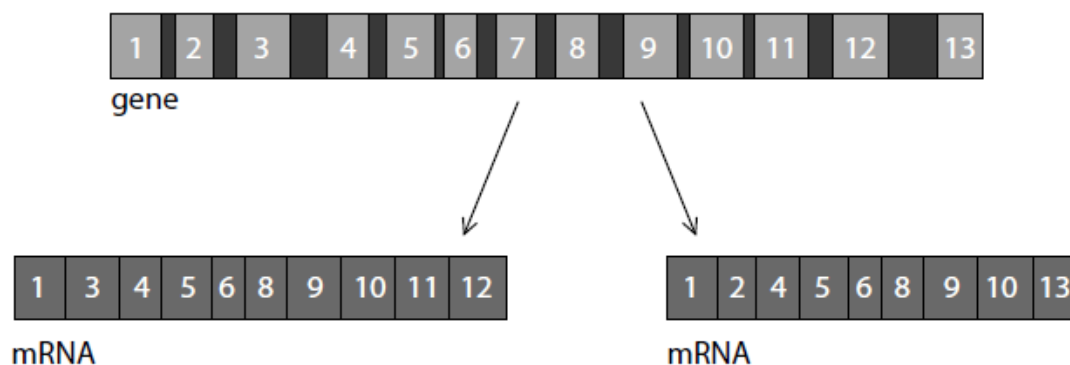
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(Total for question = 4 marks)

Q4.

A central idea in biology is that DNA codes for the synthesis of proteins from amino acids. The instructions for making proteins are in the form of mRNA.

The diagram below shows a method by which mRNA can be produced.



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An initial estimate of the number of genes, based on the number of proteins found in humans, was in the region of 100 000. It is now known that the number of genes is around 25 000.

Explain how the formation of mRNA, shown in the diagram, might account for this.

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(Total for question = 5 marks)

Q5.

A student carried out an investigation to compare the antibacterial effect of a garlic extract with that of three antibiotics, all at the same concentration.

(a) (i) To obtain the extract, a clove of garlic was cut into lots of small pieces and soaked in 0.1% ethanol for a long time.

Explain why this is an effective method of extraction.

(2)

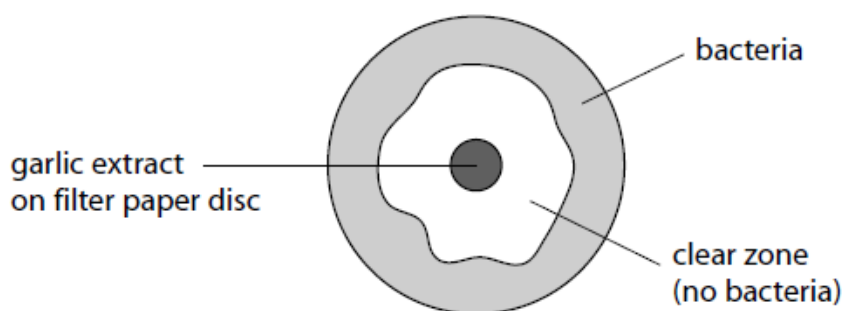
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(ii) The diagram shows the effect of the garlic extract on bacteria growing on an agar plate.



The area of the clear zone was calculated by assuming it is a circle and estimating the diameter. The estimate made was 4.3 cm.

Calculate the estimated area of the clear zone.

(2)

Answer

(b) The results of the investigation are shown in the table.

Sample number	Estimated area of clear zone / mm ²			
	Antibiotics			Plant extract
	Chloramphenicol	Tetracycline	Streptomycin	Garlic
1	28	16	15	20
2	26	19	13	28
3	29	11	14	18
4	28	21	12	25
5	26	7	14	27
6	29	11	15	26
7	22	8	9	25
8	25	21	14	25
9	29	10	12	29
Mean	27	14	13	25
Standard deviation	2.37	5.54	1.90	3.60

These data were analysed using *t*-tests.

(i) Several statistical tests were available to the student to analyse these data, including the *t*-test, Chi squared and the correlation coefficient.

Explain why the *t*-test was chosen to analyse these data, rather than the other two tests.

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(ii) Calculate the *t* value for the data to compare garlic with chloramphenicol, using the formula:

$$t = \frac{|\bar{X}^1 - \bar{X}^2|}{\sqrt{\left(\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}\right)}}$$

(3)

Answer

(iii) The table shows the critical values of t with 16 degrees of freedom.

Significance level (p)	0.20	0.10	0.05	0.01	0.001
Critical value of t	1.34	1.75	2.12	2.92	4.02

Use your value of t to test the validity of a stated null hypothesis.

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(c) The size of the clear zone depends on variables other than the antibacterial properties of the substances used, such as size and solubility of the antimicrobial molecules in the extract.

A new method was developed in which the minimum concentration of extract that causes inhibition of bacterial growth (Minimum Inhibitory Concentration, MIC), was found.

Samples of extract, bacteria (*E. coli*) and a respiration indicator were placed in a micro-titre tray.

	A	B	C	D	E	F	G	H
1								
2								
3								
4								
5								
6								
7								
8								

1 = 4%

2 = 2%

3 = 1%

4 = 0.5%

5 = 0.25%

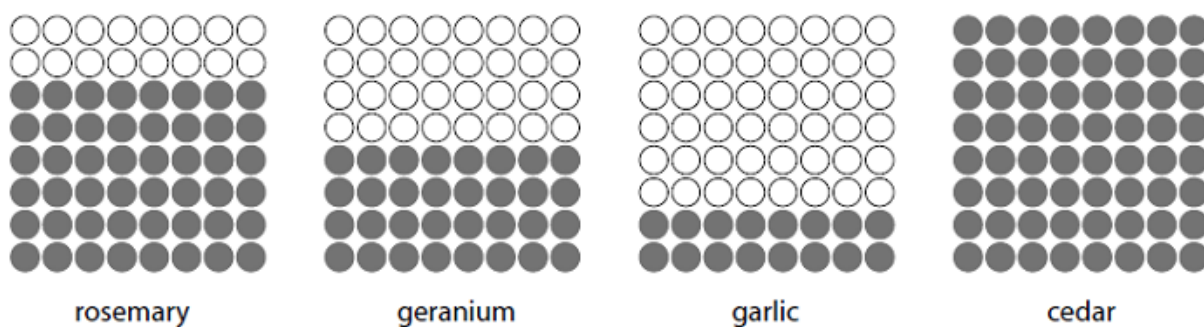
6 = 0.125%

7 = 0.0625%

8 = 0.0%

concentration of extract

The diagrams show the results obtained. The tubes are black when respiration occurs and clear when no respiration occurs.



(i) Analyse the data to explain the results of this experiment.

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(ii) Give **two** changes that can be made to the procedure to get a more accurate measure of MIC.

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(iii) It was concluded that plant extracts inhibit respiration of bacteria. This conclusion may not be valid because the investigation has limitations.

Describe how the investigation could be modified to reduce the effect of two named limitations.

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Q6.

The scientific article you have studied is adapted from an article from '*The Scientist*'.

Use the information from the scientific article and your own knowledge to answer the following questions.

Explain how the production of antibiotics by *Streptomyces* species can reduce interspecific competition (paragraph 20).

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(Total for question = 3 marks)

Q7.

Penicillin is an antibiotic. It was discovered in 1928. Since then many antibiotics have been identified and are widely used in the treatment of bacterial infections.

Scientists have recently discovered a new class of antibiotics that bind to ribosomes.

(i) Explain why these antibiotics could affect the production of proteins in bacteria.

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(ii) These new antibiotics attach to a site on the ribosome not affected by any known antibiotics.

Deduce why these new antibiotics might be used to treat bacteria that are resistant to other antibiotics.

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* (iii) Scientists have isolated these new antibiotics and tested their effectiveness against bacteria that are resistant to other types of antibiotic.

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(Total for question = 11 marks)

Q8.

Human papilloma virus (HPV) is a DNA virus.

Cervarix and Gardasil have been used in national vaccination programs.

A person who has been vaccinated becomes infected with HPV-16. Explain the role of the T cells in the body of this person.

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(Total for question = 3 marks)

Q9.

The scientific article you have studied is adapted from the book called The Immortal Life of Henrietta Lacks by Rebecca Skloot. Published by Pan Books in 2011.

(a) Explain what is meant by the term **mitosis** (paragraph 7).

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(b) The genome makes sure that cells 'do their jobs, whether that's controlling your heartbeat or helping your brain understand the words on this page' (paragraph 10).

Describe how cells in the sino-atrial node (SAN) are involved in controlling heart rate.

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(c) Henrietta's cells have 'been used to study lactose digestion' (paragraph 16).

Suggest how her cells may have digested lactose.

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(d) 'Like guinea pigs and mice, Henrietta's cells have become the standard laboratory workhorse' (paragraph 16).

Suggest **two** reasons why it is preferable to use Henrietta's cells in medical research, rather than using guinea pigs and mice.

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*(e) 'By the end of 1951, the world was in the midst of the biggest polio epidemic in history' (paragraph 19). This was caused by poliovirus which can lead to paralysis (paragraph 20).

The virus infects motor neurones which can stop skeletal muscles from working.

Suggest how an infection of motor neurones by the virus can stop the transmission of nerve impulses and lead to muscle paralysis.

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(f) Poliovirus, like Human Immunodeficiency Virus, is a retrovirus. Poliovirus was able to infect HeLa cells (paragraph 25).

Give **three** similarities between the structure of the genetic material in poliovirus and the genetic material in HeLa cells.

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(g) Scientists had studied genes by breeding plants 'then breeding their offspring to see how genetic traits are passed from one generation to the next' (paragraph 33).

When this was done using a smooth pea and a wrinkled pea, it was found that in the F2 generation (second generation of offspring), 75% were smooth.

In the space below, draw genetic diagrams to describe and explain the genotypes of the parents and their offspring in the previous **two** generations.

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(h) Explain what is meant by the term **human genome map** (paragraph 37).

(2)

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(i) Suggest how the 'p53 tumor suppressor gene' (paragraph 43) could stop a potential tumour cell forming.

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(j) Using paragraph 46, suggest what the 'specific DNA sequence from a blood cell' coded for.

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(k) A human telomere (paragraph 60) contains 10 000 nucleotides. Using information from paragraph 58, state the number of telomere nucleotides lost per cell division.

(1)

Answer nucleotides

(Total for question = 30 marks)

Q10.

One role of the skin is to protect the body from infection.

(i) Explain how skin flora protect the body from infection.

(2)

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(ii) The skin produces lipids that protect the body from infection.

Place a cross ☒ in the box next to the correct explanation of how these lipids protect the body from infection.

(1)

- ☒ **A** they are alkalis that kill bacteria
- ☒ **B** they have antimicrobial properties that inhibit the growth of bacteria
- ☒ **C** they are enzymes that destroy viruses
- ☒ **D** they are water soluble and prevent viruses from replicating

Q11.

The human gut contains more than a thousand species of bacteria. Only 30 to 40 of these species are found in the stomach.

Explain why there are relatively few species of bacteria in the stomach.

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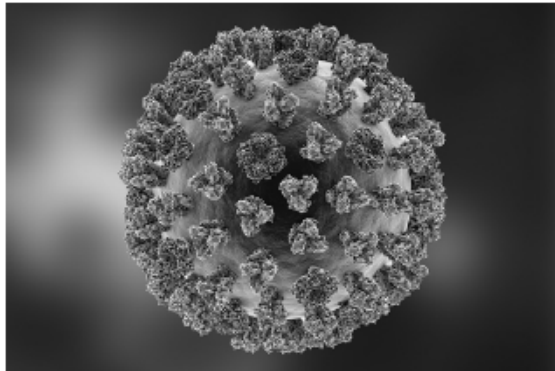
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(Total for question = 2 marks)

Q12.

The diagram shows an RNA virus that causes influenza.

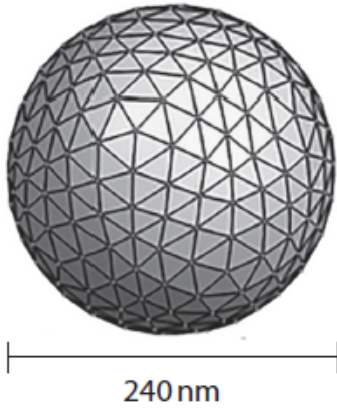


(Source: © Kateryna Kon/Shutterstock)

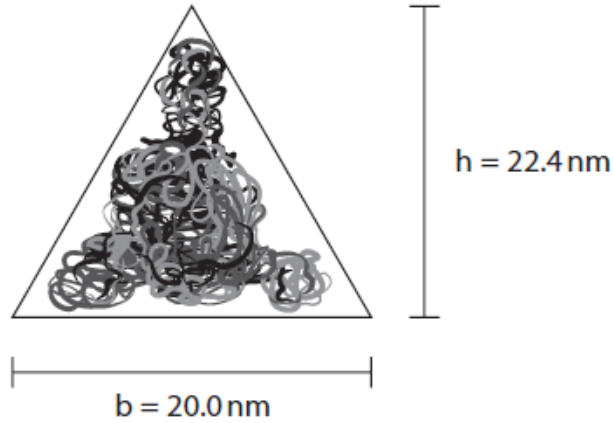
The surface of this virus capsid is covered with 'spike' proteins.

The diameter of the capsid of this virus is 240 nm.

Diagram of the surface of the virus showing each spike protein as a triangle



The diagram shows the area occupied by one spike protein



Calculate the maximum number of spike proteins that can be packed on the surface of one virus particle.

The formula for calculating the surface area of a sphere is $4\pi r^2$

The formula for calculating the area of a triangle is $\frac{h \times b}{2}$

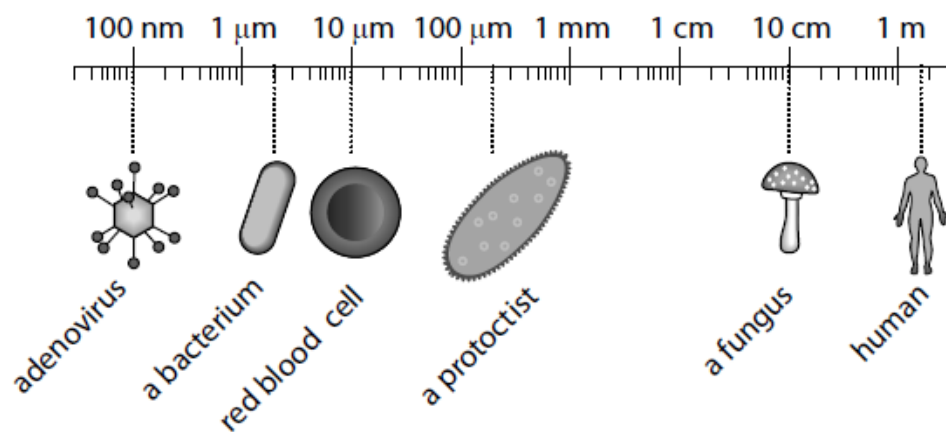
(3)

Answer

(Total for question = 3 marks)

Q13.

The diagram compares the size of some microbes with that of a human and a human cell.



© Society for General Microbiology

(a) Which of the following belong to the domain Eukaryota?

(1)

- ☐ **A** adenovirus, bacterium and protoctist
- ☐ **B** human, bacterium and red blood cell
- ☐ **C** human, red blood cell and protoctist
- ☐ **D** adenovirus, fungus and human

(b) Which of the following do **not** have a nucleus?

(1)

- ☐ **A** bacterium and protoctist
- ☐ **B** bacterium and red blood cell
- ☐ **C** fungus and adenovirus
- ☐ **D** protoctist and adenovirus

(c) Which of the following shows how many times bigger the bacterium is than the adenovirus?

(1)

- ☐ **A** 45 times
- ☐ **B** 22 times
- ☐ **C** 2 times
- ☐ **D** 10 times

(d) State **one** way in which the structure of a virus is different from that of a bacterium.

(1)

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(Total for question = 4 marks)

Q14.

The scientific article you have studied is adapted from an article from '*The Scientist*'.

Use the information from the scientific article and your own knowledge to answer the following questions.

Describe the structure of the 'protein-synthesis machinery' in bacteria (paragraph 20).

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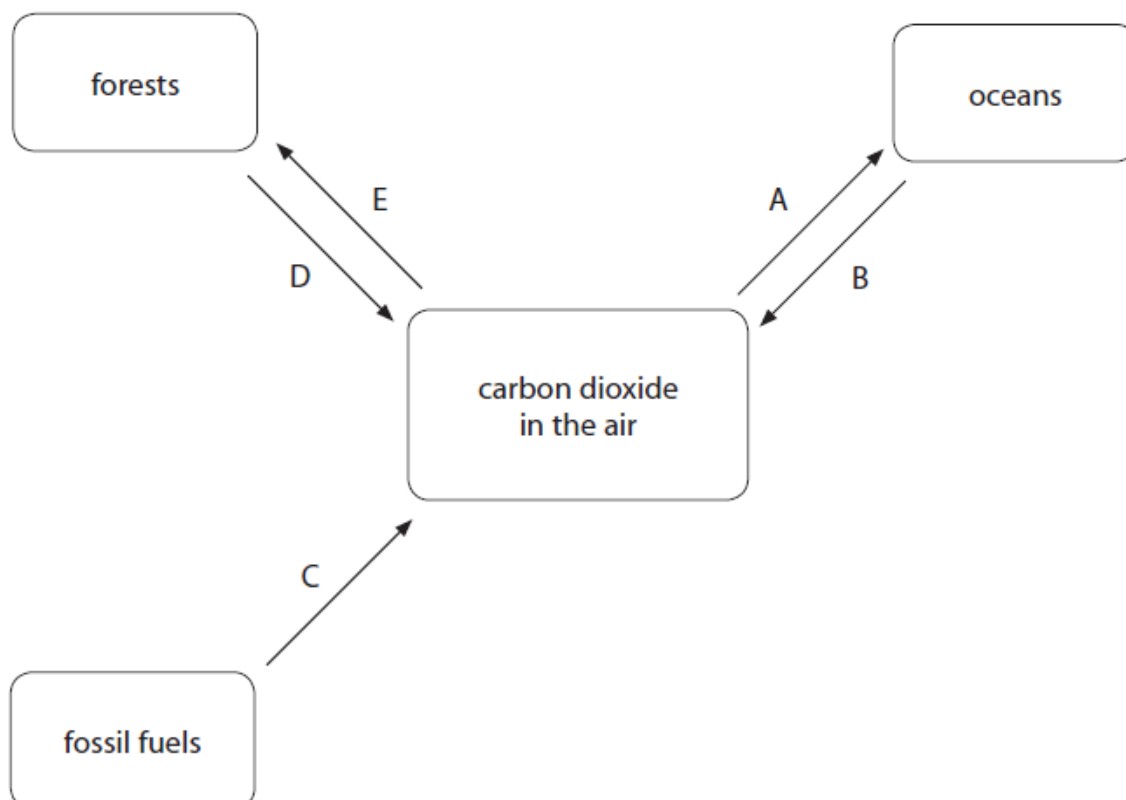
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(Total for question = 2 marks)

Q15.

The diagram below shows part of the carbon cycle. The processes A, B, C, D and E, transfer carbon.



Suggest how carbon dioxide is returned to the air from the oceans by process B.

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Q16.

The table below shows how much carbon is being transferred by each of the processes in the diagram.

Process	A	B	C	D	E
Mass of carbon transferred / au	338	332	23	444	450

(i) Calculate how much more carbon is entering the air than is leaving it.

Show your working.

(2)

Answer

(ii) Suggest why more carbon is entering the air than is leaving it.

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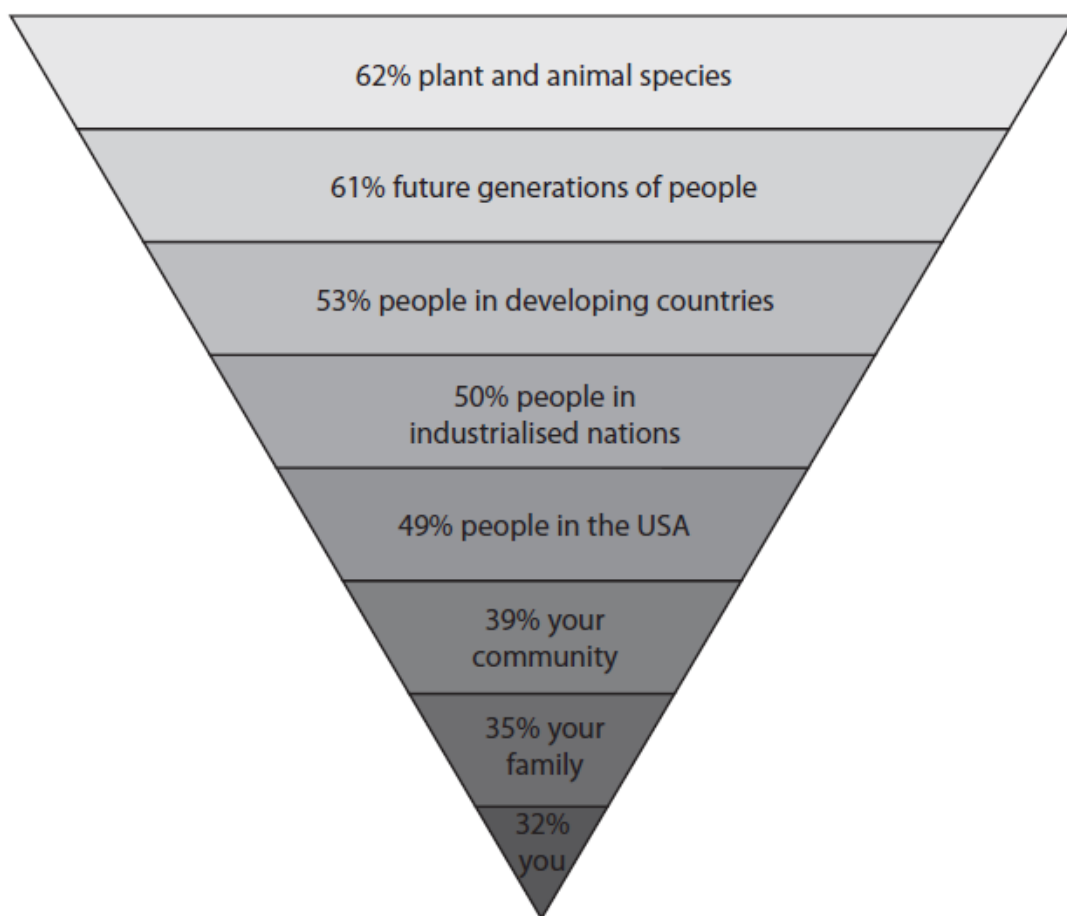
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Q17.

A survey was conducted in the USA to find out what harm people thought global warming could have.

The people were asked if they thought global warming could harm the eight groups shown in the diagram.

The diagram below shows the percentage of people who thought each group would be harmed.



This survey shows that 61% thought future generations of people could be harmed by global warming.

Suggest why the rest of the people surveyed thought that future generations of people would **not** be harmed by global warming.

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Q18.

The scientific article you have studied is adapted from *National Geographic*.

Use the information from the scientific article and your own knowledge to answer the following questions.

Explain how a vaccine developed against human plague can provide lifelong immunity to sylvatic plague in the black-footed ferret (paragraph 33).

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(Total for question = 3 marks)

Q19.

Penicillin is an antibiotic. It was discovered in 1928. Since then many antibiotics have been identified and are widely used in the treatment of bacterial infections.

State what is meant by the term bacteriostatic antibiotic.

(1)

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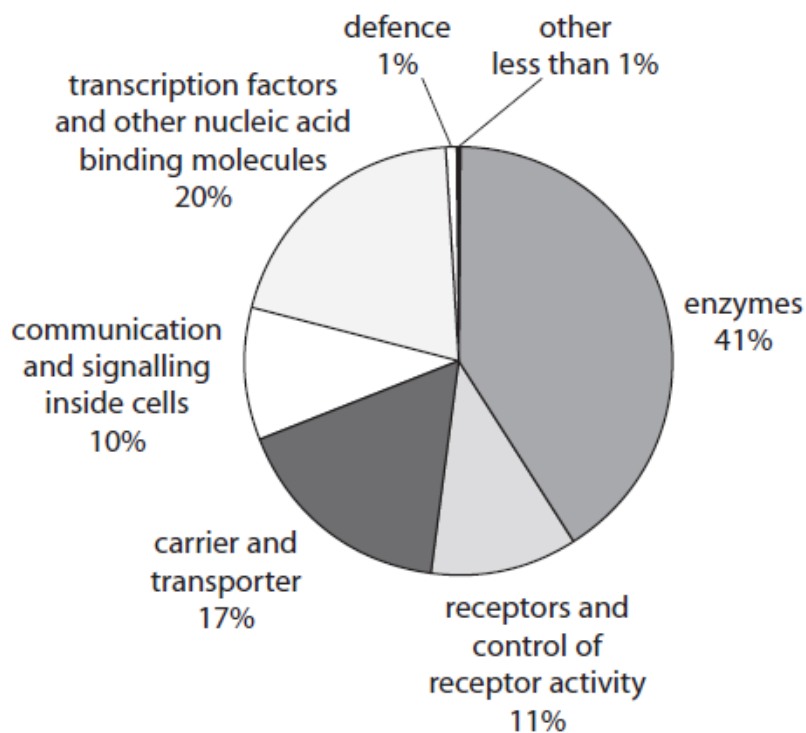
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(Total for question = 1 mark)

Q20.

* The human genome codes for approximately 20 000 different proteins.

The pie chart shows the proportion of proteins carrying out different functions.



The 20 amino acids used to make proteins can be classified according to the properties of their side chains (R groups).

Table 1 shows the number of amino acids with these properties.

Property of the side chain group	Number of amino acids with the property
Non-polar	9
Polar, uncharged	6
Negatively charged	3
Positively charged	2

Table 1

Table 2 shows three amino acids, used to synthesise proteins, that have unique properties.

Amino acid	Comment on structure
Cysteine	The side chain contains a thiol group (-S-H) that is chemically reactive.
Glycine	The side chain is a hydrogen atom which is much smaller than any other side chain. This allows tight coiling of polypeptide chains.
Proline	The side chain forms a peptide bond with the nitrogen in the amino group. This makes a polypeptide chain more rigid.

Table 2

Discuss the importance of the amino acid side chain to the structure, function and location of proteins.

(9)

(Total for question = 9 marks)

Q21.

Tuberculosis (TB) is a disease that affects the lungs. It is caused by the bacterium *Mycobacterium tuberculosis*. When these bacteria enter the body an immune response is triggered.

The Human Immunodeficiency Virus (HIV) affects the immune system. People infected with HIV are more likely to develop TB.

A study investigated the relationship between TB infections and HIV status.

In 2008, the number of people in the world estimated to have TB was 9.4 million.

The table shows the percentage of these people who were either HIV positive or HIV negative. The estimated number of deaths due to TB is also shown in the table.

HIV status	Percentage of people with TB in 2008 (%)	Estimated number of patients with TB who died in 2008	Percentage of deaths due to TB (%)
HIV positive	15	521 700	
HIV negative	85	1 278 400	16

(i) Calculate the percentage of TB patients infected with HIV who died of TB.

(2)

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(ii) Describe the effect of HIV on the number of deaths from TB.

(2)

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* (iii) There are increased numbers of deaths from TB as a result of HIV infection.

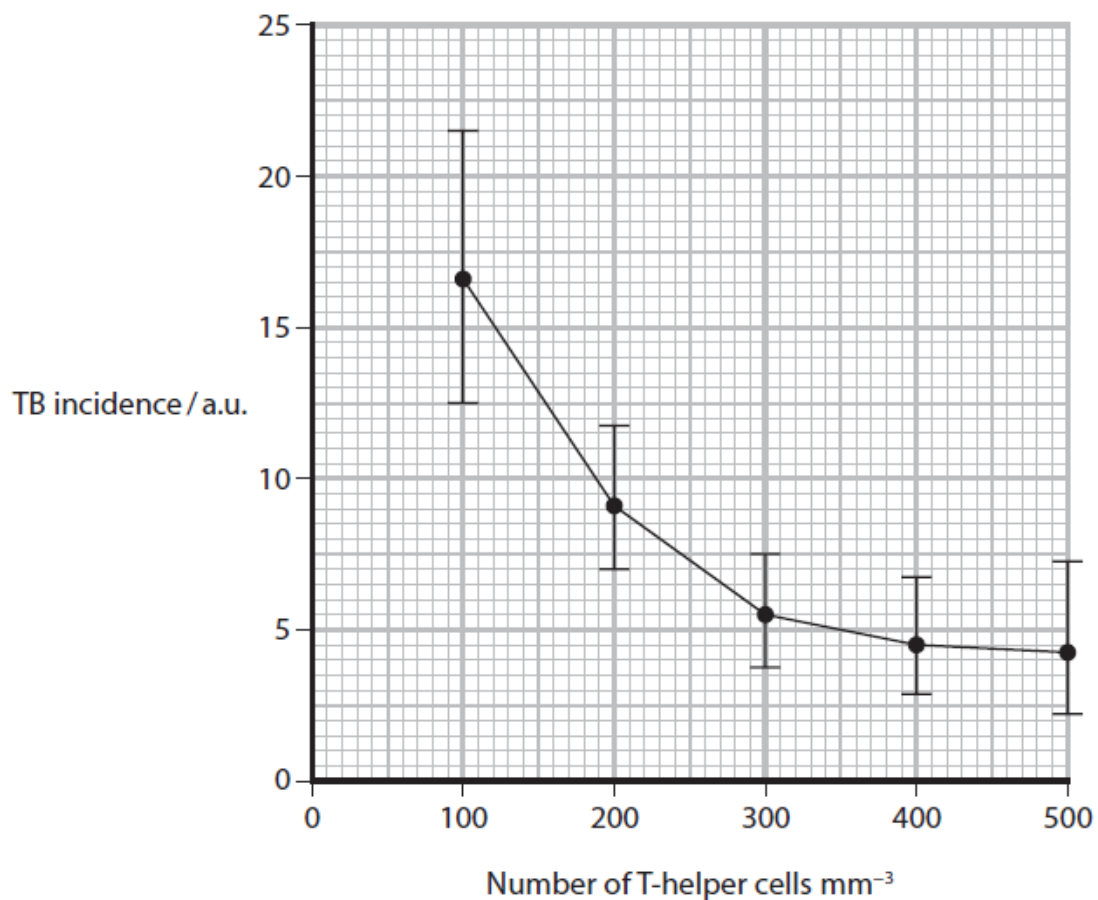
The table shows data for deaths worldwide from HIV and TB in 2016.

Type of infection	Number of deaths
TB only	1 300 000
HIV only	826 000
TB and HIV	374 000

Treatment of HIV with anti-viral drugs has reduced the incidence of TB associated with HIV infection.

The replication of HIV reduces the T-helper cell count. These anti-viral drugs reduce the replication of the virus in the body.

The graph shows the effect of this on the incidence of TB.



Explain the effect of using anti-viral drugs to treat HIV on the number of deaths from TB.

Q22.

The scientific article you have studied is adapted from *National Geographic*.

Use the information from the scientific article and your own knowledge to answer the following questions.

Explain why some pig genes can cause reactions in the human immune system (paragraph 27).

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(Total for question = 3 marks)

Q23.

Changes in the RNA of influenza produce new strains of the virus with an altered spike protein.

Devise a procedure to determine the similarity of the strains of influenza in saliva samples collected from different people.

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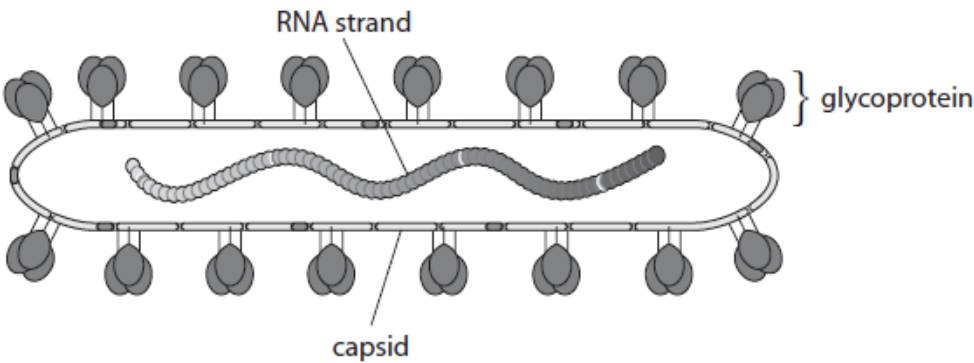
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(Total for question = 4 marks)

Q24.

Ebola virus disease (EVD) is a rare and deadly disease most commonly found in Africa. Following a severe outbreak in 2014, in which 11 000 people died, work has been underway to develop a vaccine.

The diagram shows the structure of an Ebola virus.



Compare and contrast the structure of Ebola virus with that of the human immunodeficiency virus (HIV).

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(Total for question = 3 marks)

Q25.

Tuberculosis (TB) is a disease that affects the lungs. It is caused by the bacterium *Mycobacterium tuberculosis*. When these bacteria enter the body an immune response is triggered.

The initial response when bacteria enter the body is a

(1)

- ☐ **A** non-specific response and bacteria are destroyed by antibodies
- ☐ **B** non-specific response and bacteria are destroyed by phagocytes
- ☐ **C** specific response and bacteria are destroyed by antibodies
- ☐ **D** specific response and bacteria are destroyed by phagocytes.

(Total for question = 1 mark)

Mark Scheme

Q1.

Question Number	Answer	Additional guidance	Mark
(a)(i)	- idea that interferon involved in viral infections, lysozyme affects bacteria; - idea of interferon produced by infected cells, lysozyme present in {secretions / phagocytes / neutrophils / macrophages / eq }; - interferon {inhibits / eq} {replication / eq} of viruses, lysozyme {kills / destroys} bacteria;	Piece together throughout Accept lysosome throughout Ignore pathogen throughout 2. Accept named secretion {produced / released} 3. Accept a reference to lysozyme destroying cell walls	(3)

Question Number	Answer	Additional guidance	Mark
(a)(ii)	- reference to (lysozyme) is an enzyme ; - idea that {proteins / active sites / enzymes} have a specific shape ; - idea that lysozyme acts on cell wall ; - of bacteria ;	Accept lysosome in this context	(4)

Question Number	Answer	Additional guidance	Mark
(b)(i)	- reference to histamine released as a result of damaged {tissue / cells} ; (histamine released from) {basophils / mast cells / platelets} ; - detail of effect of histamine e.g arterioles dilate, vasodilation, increased blood flow, capillaries more permeable ; - named effect of inflammation e.g. {oedema / swelling / redness / heat / pain / eq} ;	2. Accept white blood cells, macrophages and neutrophils 4. Accept raises temperature	(3)

Question Number	Answer	Additional guidance	Mark
(b)(ii)	- idea of (only) {a local reaction produced / histamines produced around bite area} ; - idea that cream {has been applied to actual site of production of histamine} ; - idea of {effect / treatment / relief / eq} {more rapid / immediate / eq} ; - idea of higher concentration of antihistamine at site ; - idea that the antihistamines will not be {digested (by enzymes) / destroyed (by acid / enzymes) / eq} ; - idea that tablets may lower immune response generally / lead to side-effects ;	2-6 Accept converse	(3)

Q2.

Question Number	Answer	Additional guidance	Mark
(a)(i)	- reference to {polymerase chain reaction / PCR} ; - polymerase (enzyme) {added / eq} ; - idea of need for primers and nucleotides ; {90-98} (°C) → {50-65} (°C) → {70-75} (°C) ; - idea that cycle needs to be repeated {several times / to make several copies of DNA / eq} ;	1. Accept as a ref to PCR machine	(4)

Question Number	Answer	Additional guidance	Mark
(a)(ii)	(DNA) {profiling / fingerprinting / (gel) electrophoresis} ;	Ignore Southern blotting, PCR Accept DNA profile / DNA fingerprint	(1)

Question Number	Answer	Additional guidance	Mark
(b)	- idea of work appearing in a (Scientific) journal or being presented at a conference ; - idea that validity or reliability is considered ; - by other scientists / ref to peer review ;	1. Accept publishing a paper, scientific meeting	(2)

Question Number	Answer	Additional guidance	Mark
(c)(i)	- reference to different {conditions / environments /eq} (in each region) ; - idea of different selection pressures ; - idea of {restricted gene flow / separate gene pools} ; - reference to reproductive isolation;	1. Accept appropriate named factor e.g. temperature 3. Ignore different allele frequency	(2)

Question Number	Answer	Additional guidance	Mark
(c)(ii)	- idea of different {alleles/ gene pool} ; - idea that this leads to {new / different} phenotypes ; - idea of new {allele / gene} can be {advantage / disadvantage} ; - reference to (advantageous) {(mutated) gene / (new) allele} passed onto offspring ;	1. Ignore allele frequency 2. Accept traits / characteristics / features	(2)

Q3.

Question Number	Answer	Additional guidance	Mark
(i)	using carbon (14) dating	ALLOW the deeper the layer in the peat, the older it is	graduate (1)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to three of the following • conditions are anaerobic (1) • therefore less (aerobic) respiration by decomposers (1) • acidic conditions {inhibit /denature} enzymes (1) • therefore (enzymes) cannot {digest / break down} organic material (1)	ALLOW (waterlogging) reduces the oxygen content ALLOW microorganisms / named decomposers ALLOW decomposers respiring anaerobically ALLOW description of denaturing eg change in shape of active site ALLOW break down plants / animals /peat	Expert (3)

Q4.

Question Number	Acceptable Answer	Additional guidance	Mark
	An explanation that makes reference to the following: • it was assumed that one gene makes one protein (so there should be 100 000 genes but there are 25 000 genes) (1) • the diagram shows that one gene can make more than one mRNA (1) • one gene can code for several proteins (1) • due to removal of different exons (1) • reference to post-transcriptional change (1)		(5)

Q5.

Question Number	Acceptable Answer	Additional guidance	Mark
(a)(i)	An explanation that makes reference to the following: • (small pieces) provides large surface area to volume ratio (1) • (use of ethanol for a long time means) the antibacterial substance is soluble in ethanol and more will be extracted (1)		(2)

Question Number	Acceptable Answer	Additional guidance	Mark
(a)(ii)	$\pi 2.15^2$ (1) 14.5 cm ² (1)		(2)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(i)	An explanation that makes reference to the following: • the <i>t</i>-test assess the significance of the difference between the means of the two treatments (1) • Chi squared not appropriate because there are no expected values (1) • correlation coefficient not appropriate because the independent variable is discontinuous / not continuous (1)		(3)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(ii)	$2.37^2 \div 9 = 0.62$ and $3.60^2 \div 9 = 1.44$ (1) $\sqrt{0.62 + 1.44} = 1.44$ (1) $(27 - 25) \div 1.44 = t = 1.39$ (1)	Correct answer gains full marks	(3)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(iii)	An answer that makes reference to the following: • there is no significant difference between the clear area caused by garlic compared with that caused by chloramphenicol (1) • $p > 0.05$ (1) • difference due to chance (1) • therefore accept null hypothesis (1)	Allow marking points for the calculated value of <i>t</i> from the candidate	(4)

Question Number	Acceptable Answer	Additional guidance	Mark
(c)(i)	An explanation that makes reference to the following: - suggests cedar wood oil has no anti-microbial effect on <i>E. coli</i> and all other oils do (1) - quoting at least two values from: rosemary 2%, geranium 0.5%, garlic 0.125% / manipulation of data to show relative effects (1)		(2)

Question Number	Acceptable Answer	Additional guidance	Mark
(c)(ii)	An answer that makes reference to the following: - for cedar wood oil try concentrations above 4% (1) - for all the others, try concentrations below 0.0625% (1)		(2)

Question Number	Acceptable Answer	Additional guidance	Mark
(c)(iii)	A description that makes reference to the following: - only one tray per species – need repeated measurements (1) - species – only used one species of bacteria / only used extracts from four plant species (1)		(2)

Q6.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to three of the following: - antibiotics reduce the number of other (species of) bacteria (1) - antibiotics that attack cell walls {cause lysis / are bactericidal } (1) - antibiotics that attack protein synthesis (machinery) {prevent growth / are bacteriostatic} (1) - this reduces interspecific competition from other bacteria for limited resources (1)	ALLOW attack ribosomes	(3)

Q7.

Question Number	Answer	Additional guidance	Mark
(i)	An explanation that makes reference to three of the following • ribosome shape is altered (1) • mRNA is prevented from binding (to the ribosome) / causing change in tRNA binding (1) • therefore translation cannot occur (1) • { protein / polypeptide } is not synthesised (1)	ALLOW translation is affected / reduced / altered ALLOW faulty protein produced	(3)

Question Number	Answer	Additional guidance	Mark
(ii)	An answer that makes reference to two of the following • bacteria have not been exposed to new antibiotics before / bacteria do not have mechanisms to make them resistant to the new antibiotics (1) • bacteria have developed resistance (to other antibiotics) by { evolving / natural selection } (1) • therefore there has been {no advantage to possessing a mutation to bypass the new antibiotic / no mutation present to give resistance } (1)		(2)

Question Number	Answer	Mark
(iii)	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. Indicative content • prepare agar plates with bacterial cultures / bacterial lawn / seeded with bacteria –use bacteria that are resistant to other antibiotics • prepare solutions of new antibiotic and penicillin • place onto paper discs / into wells in the agar / prepare mast rings • control time and temperature of incubation • same concentration and volume of both antibiotics • measure the area of inhibition • repeat for effective antibiotics • description of serial dilution of each antibiotic • range of dilutions on each plate-one antibiotic per plate • statistical test to determine which is the most effective • repeat with different strains of resistant bacteria	(6)

Level	Marks		Additional Guidance
0	0	No awardable content	
1	1-2	An explanation of how the investigation should be modified may be attempted but with limited analysis, interpretation and/or evaluation of the scientific information. Generalised comments made. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.	Preparation of agar plates Method of adding antibiotic Use of new antibiotic and penicillin Measure zone of inhibition
2	3-4	An explanation of how the investigation should be modified will be given with occasional evidence of analysis, interpretation and/or evaluation of the scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.	Incubated for stated time 24-72 hours Incubated at stated temperature 25-37°C Method of culturing bacteria on agar plates/preparing a lawn Repeats to calculate the mean Larger zone of inhibition-more effective antibiotic
3	5-6	An explanation of how the investigation should be modified is given which is supported throughout by evidence from the analysis, interpretation and/or evaluation of the scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear, coherent and logically structured.	Strain of bacteria known to be resistant to penicillin/other antibiotics Same volume/concentration of both antibiotics Several strains of resistant bacteria tested with new antibiotic Preparation of serial dilutions for both antibiotics Range of concentrations give minimum effective dose Named statistical test eg T-test

Q8.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to three of the following: • a vaccinated person will have memory T cells (1) • (memory T cells) recognise (antigens specific to) the HPV-16 virus (1) • T helper cells that activate {B cells / T killer cells} (1) • (formation of) T killer cells destroy cells infected with virus (1)	ALLOW a response that begins with 'T memory cells ...' / or statement that T memory cells are already present ALLOW cytotoxic T cells for T killer cells	3

Q9.

Question Number	Answer	Additional Guidance	Mark
(a)	1. involves prophase, metaphase, anaphase and telophase ; 2. idea that produces two nuclei ; 3. idea that these are genetically identical to original ;	1. NOT if cytokinesis or interphase included as part of mitosis 2. ACCEPT produces two cells	(2)

Question Number	Answer	Additional Guidance	Mark
(b)	1. (SAN) is myogenic / description given ; 2. electrical activity from SAN causes atria to contract / eq ; 3. idea that activity of SAN can be changed by nerve impulses e.g. controlled by medulla ; 4. credit detail of nervous control e.g. more impulses from accelerator increases heart rate ;		(3)

Question Number	Answer	Additional Guidance	Mark
(c)	1. idea that lactase gene {activated / transcribed} ; 2. (synthesis of) lactase / eq ; 3. hydrolysis of lactose / glycosidic bonds broken ; 4. to produce glucose AND galactose ;		(3)

Question Number	Answer	Additional Guidance	Mark
(d)	1. idea that a better model than guinea pigs or mice ; 2. idea of animal rights ; 3. easy to culture / eq ; 4. (HeLa cells) susceptible to disease / HPV / eq ;	1. ACCEPT reference to only HeLa {cells / DNA} are human 3. ACCEPT cheaper (as continual supply)	(2)

Question Number	Answer	Additional Guidance	Mark
* (e)	(QWC – spelling of technical terms must be correct and the answer must be organised in a logical sequence) 1. idea that {motor neurone / cell body / nucleus} is destroyed ; 2. depolarisation does not occur in the neurone / (insufficient so) no action potential set up in the neurone ; 3. detail of (depolarisation / action potential) not occurring in neurone e.g. idea Na^+ does not diffuse into neurone ; 4. {neurotransmitter / named neurotransmitter} not {released / produced / eq} at junction with muscle / eq ; 5. detail of lack of neurotransmitter release e.g. vesicles (containing neurotransmitter) do not {move / fuse} with {presynaptic membrane /	QWC emphasis is clarity of expression 1. ACCEPT idea of damage to myelin sheath / Schwann cells 3. ACCEPT Na^+ / cation channels {non-functional / eq} 4. ACCEPT {neurotransmitter / named neurotransmitter} not {released / produced / eq} at {motor neurone presynaptic membrane / motor end plate}	

	eq} / eq ; 6. Ca^{2+} not released into muscle cytoplasm ; 7. Ca^{2+} not released from sarcoplasmic reticulum ; 8. no Ca^{2+} to {activate / eq} troponin ; 9. idea that muscle does not contract ;	6. ACCEPT Ca^{2+} not released into sarcoplasm	(6)
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Question Number	Answer	Additional Guidance	Mark
(f)	1. contains bases / eq ; 2. contain phosphate (groups) ; 3. have a pentose sugar ; 4. reference to phosphodiester bonds ; 5. idea of discrete strands ;	1. ACCEPT both have (4) bases / nucleotides 3. ACCEPT 5C sugar 5. ACCEPT linear	(3)

Question Number	Answer	Additional Guidance	Mark
(g)	1. smooth shown as dominant / wrinkled shown as recessive e.g. use of upper and lower case ; Parental generation: 2. both types shown as homozygous ; F1: 3. all shown as heterozygous ; F2: 4. genetic diagram to show that 75% are smooth / 25% are wrinkled ;	4. Diagram should show genotypes	(4)

Question Number	Answer	Additional Guidance	Mark
(h)	- all the {DNA / eq} found in {a human / the human species / eq} ; - idea of genes {on different chromosomes / different positions on same chromosome} ;	1. ACCEPT population for species	(2)

Question Number	Answer	Additional Guidance	Mark
(i)	- product (of p53 gene) {stops / eq} development of tumour cells / eq OR - product (of p53 gene) {stops / regulates} progression {of cell cycle / towards mitosis} ; - acts as an inhibitor of {transcription / protein synthesis / eq} / eq ; - idea that {DNA / eq} repair ; - idea that leads to apoptosis ;	- ACCEPT product stops tumour cells growing / dividing - ACCEPT product keeps it in {interphase / named mitotic stage} / product interferes with mitosis progress	(2)

Question Number	Answer	Additional Guidance	Mark
(j)	- protein / glycoprotein ; - reference to this being CD4 ; - found on cell (surface) membrane / eq ; - that acts as a {receptor / named receptor} for HIV / eq ;	4. ACCEPT receptor for gp120	(2)

Question Number	Answer	Mark
(k)	200 (nucleotides) ;	(1)

Q10.

Question Number	Answer	Additional Guidance	Mark
(i)	1. (skin flora) {prevent growth of / kill} {pathogens / microorganisms / bacteria / eq} ; 2. competition for {space / nutrients / water / minerals / eq} ; 3. release of {chemicals / toxins / antimicrobials / lipids / enzymes /eq } ;	1 ACCEPT prevent colonisation IGNORE antigens / viruses / infections / diseases 2 IGNORE food / resources 3 NOT sebum / lysozymes	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	B they have antimicrobial properties that inhibit the growth of bacteria		(1)

Q11.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to two of the following - because the pH inside the stomach is too low for the enzymes of most bacteria to function (1) - bacteria that live in the stomach have adaptations that enable them to survive (1)	ALLOW reference to bacterial enzymes being denatured ALLOW (some) bacteria have evolved specifically to withstand the conditions	(2)

Q12.

Question number	Answer	Additional guidance	Mark
	• surface area of virus (1) • surface area of one spike protein (1) • correct whole number (1)	Example of calculation $4 \times \pi \times 120^2 = 180955.7 \text{ (nm}^2\text{) ALLOW 180864 / 181028.6}$ $(22.4 \times 20) \div 2 = 224 \text{ (nm}^2\text{)}$ $180955.74 \div 224 = 808 \text{ ALLOW 807}$ ECF for one incorrect area values For a maximum of 2 marks Correct answer with no working gains full marks.	Expert (3)

Q13.

Question Number	Acceptable Answer	Additional guidance	Mark
(a)	C		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)	B		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(c)	B		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(d)	An answer that makes reference to one of the following points: • virus has a non-cellular structure whereas bacteria has a cellular structure (1) • a virus has a protein capsid whereas a bacterium has a polysaccharide cell wall (1) • viruses have one type of nucleic acid whereas a bacterium has two (1)		(1)

Q14.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to two of the following: • (70S) ribosome (1) • larger and smaller subunits (1) • containing protein and rRNA (1)		(2)

Q15.

Question Number	Answer	Additional Guidance	Mark
	respiration / decomposition / eq ;	ACCEPT description NOT photosynthesis	(1)

Q16.

Question Number	Answer	Additional Guidance	Mark
(i)	Correct answer gains both marks $\{332 + 23 + 444 / 799\}$ and $\{338 + 450 / 788\}$; $(799 - 788) = 11$ (au) ;	CE applies	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	- idea that rate of production of carbon dioxide is greater than rate of removal of carbon dioxide ; - idea of using of {fossil fuels / named fossil fuel / forests / eq} {releasing / producing} carbon dioxide ; - idea that this carbon (in fossil fuels / forests) was {locked up / removed from the air } years ago ; - idea of deforestation resulting in less {photosynthesis / carbon fixation / light independent reaction / eq} ;	1 ACCEPT carbon dioxide {production / release} is greater than used in photosynthesis 3 ACCEPT ref to carbon sink 4 ACCEPT less carbon dioxide used for photosynthesis	(3)

Q17.

Question Number	Answer	Additional Guidance	Mark
	1. idea that we can only {make predictions about the future / extrapolate data / work on correlations / eq } ; 2. idea that {scientists / industry / eq} are presenting {different views / insufficient evidence / eq} about global warming ; 3. idea that some people surveyed did not {understand / know about} global warming ; 4. idea that some people do not believe in {global warming / harmful effects of global warming} because they do not want it to affect their { lifestyle / named lifestyle / eq } ; 5. idea that some people think that a solution to global warming will be found ; 6. idea that some people do not want to think about the future ;	NB just a reference to do not believe is too vague 1 ACCEPT it is due to natural cycle / normal fluctuations	(3)

Q18.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to three of the following: - the same bacteria causes human plague and sylvatic plague (1) - antigens in the (human plague) vaccine are processed and presented to lymphocytes (in the black-footed ferret) (1) - therefore stimulating active immunity (to sylvatic plague) (1) - and producing memory cells (to these antigens) (1)	ALLOW the bacteria causing human plague and sylvatic plague have the same antigens ALLOW enabling a secondary immune response	(3)

Q19.

Question Number	Answer	Additional guidance	Mark
	A substance which can (inhibit the growth / prevent multiplication) of bacteria		(1)

Q20.

Question number	
*	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. Indicative content Information • there are 20 000 different proteins • these proteins carry out different functions • there are a {large number of / 20} different {R groups / amino acids} • most R groups are non-polar, some are polar a few have a charge Linkage to structure • R groups determine {3D shape / structure} of proteins • {large number of / 20 R groups} • many combinations of amino acids required to give wide variety of protein structures • R groups can form bonds to stabilise 3D structure (e.g. cysteine) • role of R-groups in structure of haemoglobin • role of R-groups in structure of collagen • location of cysteine allows formation of disulfide bonds Linkage to function • R groups variety of protein shapes are required to allow proteins to carry out wide range of functions • examples of functions that require specific structure e.g. antibodies specific to an antigen / enzymes specific for a substrate / receptors e.g. neurotransmitters and (acetylcholine) and ion-gated channels • polar / ionic R groups increase solubility • non-polar R groups will be on outside of insoluble proteins / structural proteins / collagen / proteins inserted into membranes • role of R-groups in function of haemoglobin • role of R-groups in function of collagen Linkage to location • polar R groups will be in aqueous environment / non-polar regions in a non-aqueous environment

	• polar / ionic R groups soluble in {plasma/ tissue fluid / cytoplasm} / line the inside of ion channels / found on the outside of soluble proteins such as hormones / transport proteins / immunoglobulins / cytokines • role of R-groups in location of haemoglobin • role of R-groups in location of collagen
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Level	Marks		
0	0	No awardable content	
1	1-3	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context.	Selection of some information from the table – little or no linkage Linkage to one aspect – 2 marks Two linkages for same aspect – 3 marks
2	4-6	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.	Linkage between R groups and two aspects from structure, function and location One comment on each - 4 marks An additional comment - 5 marks An additional 2 comments – 6 marks
3	7-9	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures.	Linkage between R groups and all three aspects (structure, function and location) One comment on each - 7 marks

		The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	An additional comment - 8 marks An additional 2 comments – 9 marks
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Q21.

Question Number	Answer	Additional guidance	Mark
(i)	- calculation of the number of TB patients with HIV (1) - calculation of percentage of HIV positive TB patients that died(1)	Example of calculation 15% of 9.4 million = 1.41 million $521\,700 \div 1\,410\,000 = 0.37 = 37\%$ Correct answer with no working gains full marks	graduate(2)

Question Number	Answer	Additional guidance	Mark
(ii)	An answer that makes reference to the following - a greater percentage of patients with HIV die from TB compared with TB patients without HIV (1) - the total number of cases and deaths from TB is greater in those without HIV (1)		Expert (2)

Question Number	Answer	Mark
(iii)	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. indicative content • TB is more likely to develop in patients with HIV • Anti-viral drugs reduce the incidence of TB in patients with HIV • HIV binds to CD4 receptors on T-helper cells • HIV replicates inside T-helper cells then destroys the cells as it bursts out • This reduces the number of T helper cells • When a bacterium such as <i>M. tuberculosis</i> enters the body, the reduction in T helper cells means there is no immune response • The patient develops TB • Drugs that prevent viral replication means T-helper cells are not destroyed • The immune system can prevent TB developing • Therefore deaths from TB will decrease in patients with HIV • However, more deaths from TB are in patients without HIV, and therefore antiviral drugs will not reduce this number	Expert (6)

			Additional guidance
Level 0	Marks	No awardable content	
Level 1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.	Data described from information provided e.g. • TB incidence decreases as T helper cells increase • TB bacteria multiply in body • Use of antiviral drugs increases T helper cell numbers • Basic explanation
Level 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.	Explanation of data e.g. Overlapping error bars indicate no difference for T helper cell counts above 300 mm⁻³ HIV infects T helper cells HIV enters T helper cells and reduces the number of T-helper cells This reduces immune response Antiviral drugs prevent replication of HIV Immune response details

Level 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 and logically structured.	Detailed explanation as to how antiviral drugs prevent TB developing by preventing HIV replication inside cells. Relevant immune response detail – T helper cells activate B cells / release cytokine / result in antibody production Explanation that antiviral drugs will only reduce TB deaths in those also infected with HIV. No effect on others as antiviral drugs do not kill bacteria.
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Q22.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to three of the following: • pig genes are transcribed and translated to produce proteins (1) • the structure of (some of) these proteins will be different from those in humans (1) • these proteins will be recognised as foreign (1) • activating lymphocytes (1)	ALLOW pig genes code for antigens ALLOW recognised as antigens ALLOW trigger a specific immune response	Choose an item. (3)

Q23.

Question number	Answer	Additional guidance	Mark
	An answer that makes reference to the following: • {isolate / extract} RNA from (saliva) samples (1) • amplify the {RNA/DNA/nucleic acid} by PCR (1) • cut the {RNA/DNA/nucleic acid} into fragments (using restriction enzymes) (1) • (separate fragments using) gel electrophoresis (1) • more similar the {banding / profile} (of the fragments) the more closely related the strain (1)	ALLOW (reverse) transcribe RNA to DNA and amplify DNA ALLOW sequence the virus genome ALLOW the fewer the number of base changes the more closely related the strains	Expert (4)

Q24.

Question Number	Answer	Additional guidance	Mark
	An answer that makes reference to three of the following Similarities • both contain RNA (1) • both have {a (protein) capsid / glycoproteins} (1) Differences • Ebola contains one strand of RNA but HIV contains two strands of RNA (1) • HIV is spherical, Ebola virus is elongated (1)	IGNORE retrovirus ALLOW protein coat ALLOW HIV is icosahedral / Ebola is filamentous ALLOW HIV is round ALLOW HIV has a lipid layer/envelope and Ebola does not (acceptable on basis of diagram provided)	(3)

Q25.

Question Number	Answer	Mark
	The only correct answer is B <i>non-specific response, bacteria are destroyed by phagocytes</i> A is not correct because killer T-cells are not involved in the initial response C is not correct because the initial response is not the specific response D is not correct because the initial response is not the specific response	Computer (1)

Q1.

Tuberculosis (TB) is a disease that affects the lungs. It is caused by the bacterium *Mycobacterium tuberculosis*. When these bacteria enter the body an immune response is triggered.

M. tuberculosis bacteria can remain dormant in the body after infection.

Explain why these dormant bacteria are not destroyed by the immune system.

(3)

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(Total for question = 3 marks)

Q2.

A deer was found dead on National Trust land. Some people thought that the wounds that led to the deer's death could have been caused by a big cat such as a black panther.



Samples of DNA from the wounds of this deer were collected.

Investigators used the polymerase chain reaction (PCR) to increase the quantity of DNA in the samples.

(i) Describe how one PCR cycle would increase the quantity of DNA present.

(3)

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(ii) One PCR cycle takes two minutes.

Show that the quantity of DNA would have been amplified over one million times after 40 minutes.

(2)

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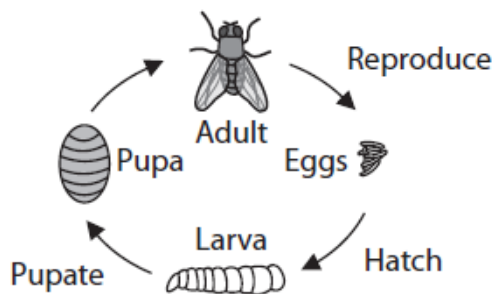
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(Total for question = 5 marks)

Q3.

Blowflies are found in many parts of the world, including Africa.

The diagram shows the life cycle of one species of blowfly (species A) found in Africa.



An investigation was carried out to find the temperature at which 50% of the larvae of this species survive. This investigation was repeated for a further six species of African blowfly larvae, B to G. All other variables were kept constant.

In another investigation, the temperature of sand that the larvae selected when ready to pupate was recorded.

A student used the data from these investigations to find out if there is a statistically significant correlation between the two sets of temperatures.

To do so, a Spearman's rank correlation coefficient can be calculated.

(i) Complete the table to rank all the data and to calculate d and d^2 for species E to G.

(3)

Blowfly species	Mean temperature at which 50% of larvae survive / °C	Rank for mean temperature for 50% larvae survival	Mean temperature of sand selected / °C	Rank for mean temperature of sand selected	Difference in rank (d)	Difference in rank squared (d ²)
A	49.0	5	26.1	7	−2	4
B	47.5	2	23.2	3	−1	1
C	48.5	3	24.7	6	−3	9
D	42.9	1	16.6	1	0	0
E	48.8		23.6			
F	50.1		24.2			
G	49.2		23.1			

(ii) Calculate the Spearman's rank correlation coefficient (r_s) using the equation:

(3)

$$r_s = 1 - \frac{6\sum d^2}{n(n^2 - 1)}$$

where $\sum d^2 = 34$ and n is the number of blowfly species.

Answer

(iii) The table shows critical values for r_s .

	Probability		
n	0.10	0.05	0.01
5	0.900	1.000	1.000
6	0.829	0.886	1.000
7	0.714	0.786	0.929
8	0.643	0.738	0.881
9	0.600	0.683	0.833

Deduce whether the data showed a statistically significant correlation.

(2)

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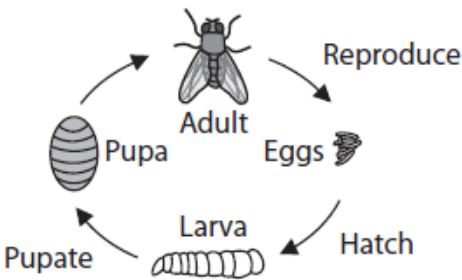
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(Total for question = 8 marks)

Q4.

Blowflies are found in many parts of the world, including Africa.

The diagram shows the life cycle of one species of blowfly (species A) found in Africa.



An investigation was carried out to find the temperature at which 50% of the larvae of this

species survive. This investigation was repeated for a further six species of African blowfly larvae, B to G. All other variables were kept constant.

In another investigation, the temperature of sand that the larvae selected when ready to pupate was recorded.

A number of observations were made about a dead rhinoceros:

- adults of all seven species of blowfly (A to G) were observed near the rhinoceros
- large numbers of living larvae of species F were present inside the rhinoceros
- mean temperature in this group of larvae was $49 \pm 1.1\text{ }^{\circ}\text{C}$
- mean temperature of the air surrounding the rhinoceros was $33 \pm 3.0\text{ }^{\circ}\text{C}$.

(i) Determine how the mean temperature of $49\text{ }^{\circ}\text{C}$ was found.

(2)

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(ii) It was observed that all the living larvae in the rhinoceros belonged to species F.

The metabolic activity of the larvae of species F increases the temperature within the dead rhinoceros.

Explain the advantages for this species of blowfly of increasing the temperature within the dead rhinoceros.

(3)

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(Total for question = 5 marks)

Q5.

A newborn baby can respond to infections.

Interferon is involved in the response to viral infections.

(i) The influenza virus can be lethal to mice.

The effects of interferon on influenza infection in mice was investigated.

Mice were infected with influenza virus and then given interferon.

The results of the investigation are shown in the table.

Interferon dose / units per mouse	Median survival time / days
No dose	3.3
8×10^3	4.4
8×10^4	8.5
8×10^5	>42

Explain these results.

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(ii) Interferon can be used to treat people with viral hepatitis.

Interferon can be made by animal cells or by genetically modified bacteria.

The table shows information about interferon made by these animal cells and genetically modified bacteria.

Source of interferon	Type of molecule	Folding	Antiviral activity
Animal cells	Glycoprotein	Correctly folded	High
Genetically modified bacteria	Protein	Incorrectly folded and needs to be refolded before it can be used	Low

Explain why the interferon made by genetically modified bacteria is different from the interferon made by animal cells.

(2)

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(iii) Glycoproteins made in animal cells are released into the extracellular fluid by

(1)

- ☐ **A** endocytosis
- ☐ **B** exocytosis
- ☐ **C** facilitated diffusion
- ☐ **D** phagocytosis

(Total for question = 6 marks)

Q6.

The chart shows a Henssge nomogram.

The steps below need to be followed to estimate the time of death using the Henssge nomogram:

Step 1

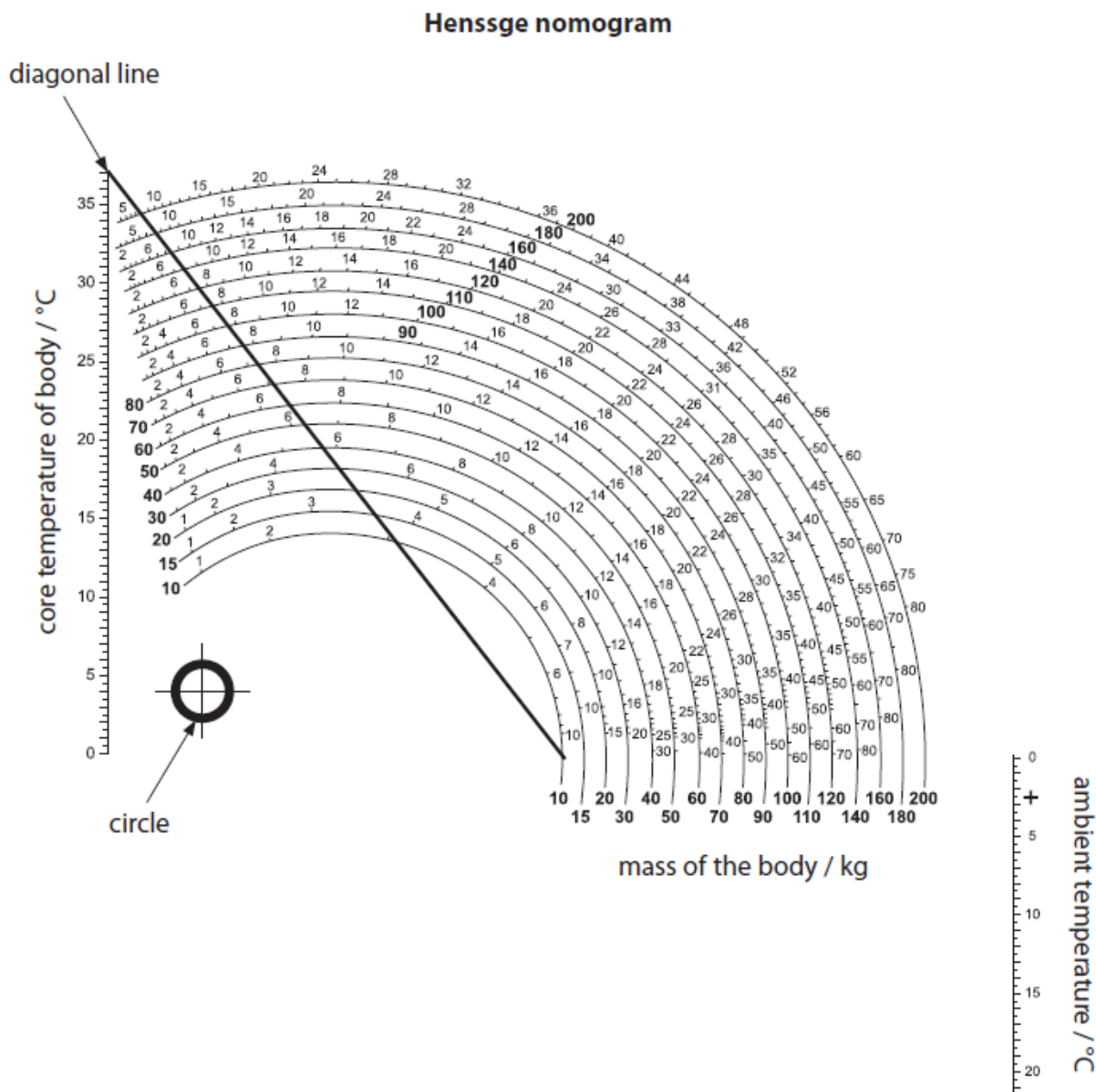
Draw a straight line between the core temperature of the body and the ambient temperature (= line 1)

Step 2

Draw a straight line that extends from the centre of the circle through the diagonal line, at the point where it crosses line 1 (= line 2)

Step 3

Read the time of death from the nomogram at the point line 2 crosses the appropriate semicircle for the mass of the body.



(i) A body was found. The mass of the body was 100 kg and the core

temperature of the body was 25°C. The ambient temperature was 15°C.

Use the Henssge nomogram to estimate the time of death.

(3)

time of death =..... hours ago

* (ii) The Henssge nomogram is used to estimate the time of death of a naked body, lying stretched out and in still air.

Suggest how a change in each of these three factors could affect the estimated time of death. Give reasons for your answer.

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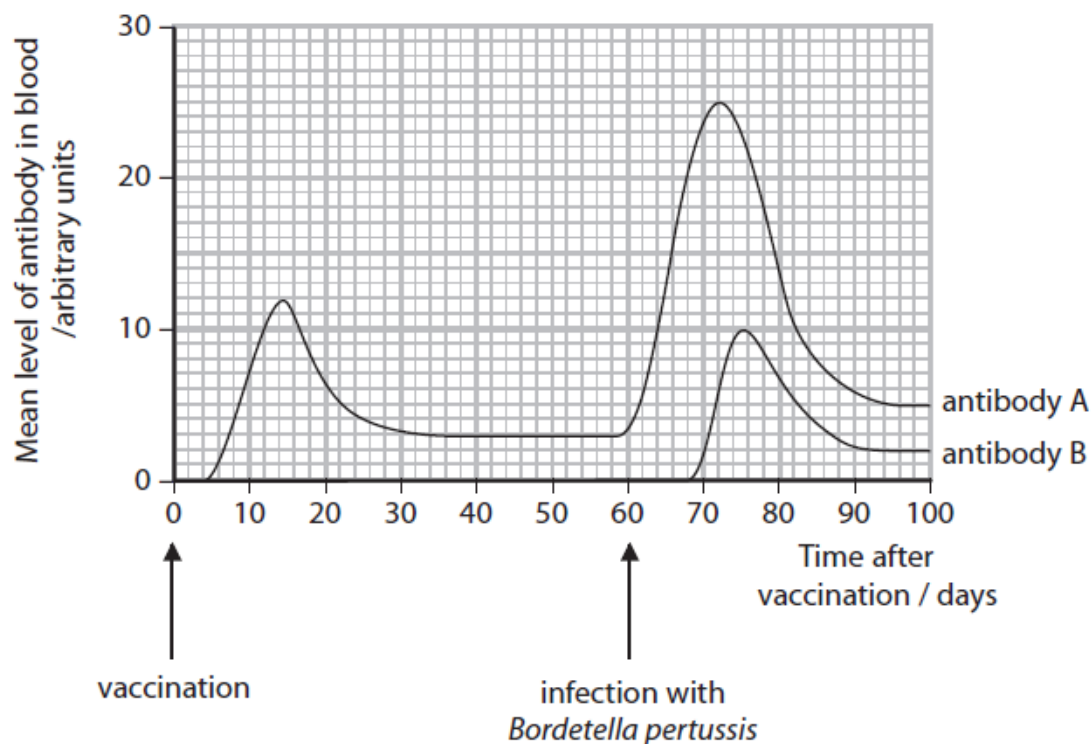
Q7.

Whooping cough is a disease that is particularly serious in young children. Whooping cough is

caused by the bacterium *Bordetella pertussis*. Children may be vaccinated against whooping cough.

In an investigation, a group of rats was vaccinated. Sixty days later these rats were infected with *Bordetella pertussis*. In this investigation, the levels of two antibodies in the blood of the rats were measured.

The graph below shows the mean levels of antibody A and antibody B.



(a) (i) For antibody A, compare the increase in mean level after the vaccination with the increase in mean level after infection with *Bordetella pertussis*.

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(ii) Explain the changes in mean level of antibody A after infection with *Bordetella pertussis*.

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(b) (i) Suggest why antibody B was not present in the blood of these rats until after infection with *Bordetella pertussis*.

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(ii) Place a cross ☒ in the box next to the term that describes the type of immunity that results in the production of antibody B.

(1)

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

(c) Comment on the reliability of the data shown in the graph.

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(Total for question = 11 marks)

Q8.

Ebola virus disease (EVD) is a rare and deadly disease most commonly found in Africa. Following a severe outbreak in 2014, in which 11 000 people died, work has been underway to develop a vaccine.

A vaccine has been developed by genetically modifying a virus that infects cattle. In the genetically modified virus, one of the genes was replaced with a gene for a protein found in the Ebola virus.

In a trial of 52 volunteers, 48 developed antibodies against the Ebola virus within 14 days of injection.

(i) The type of immunity given by this vaccine is

(1)

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

(ii) Explain the role of T cells in the immunity to the Ebola virus that develops following the use of this vaccine.

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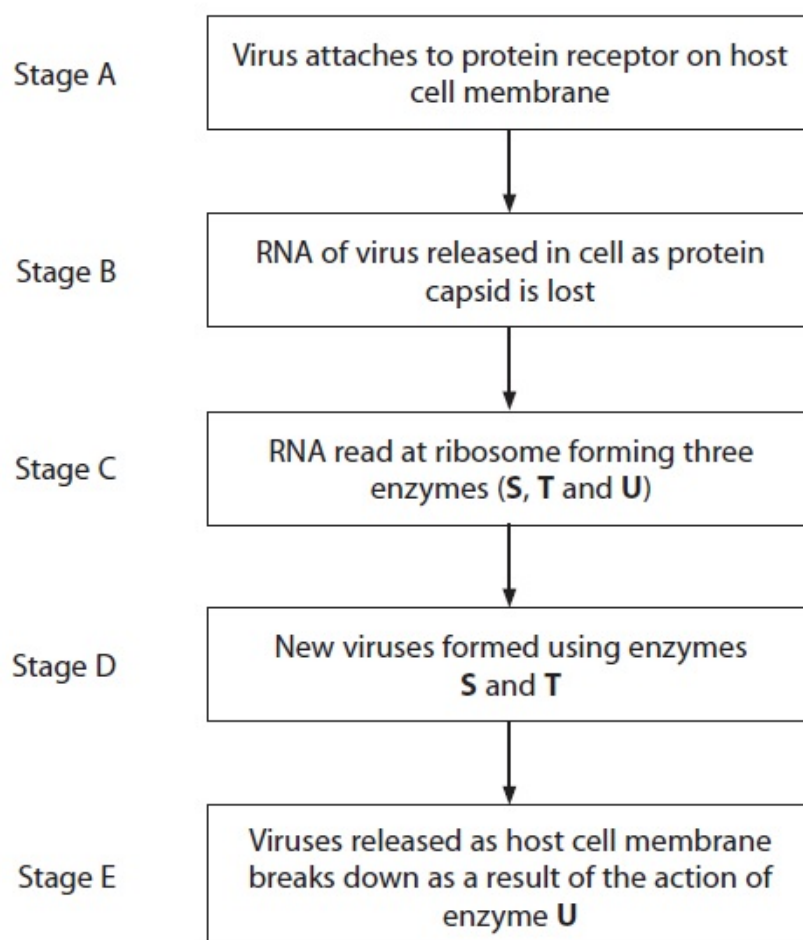
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(Total for question = 4 marks)

Q9. The common cold is a disease caused by a variety of viruses.

The flow diagram below describes how common cold viruses attack the cells on the inside of the nose.



(a) Common cold viruses infect only the cells inside the nose.

(i) Suggest why common cold viruses cannot infect cells if they land on unbroken skin.

(2)

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(ii) Suggest why common cold viruses cannot infect cells if they enter the blood through a cut in the skin.

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(b) Compare the action of the RNA in the common cold virus with that found in HIV.

(2)

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(c) At Stage C, three enzymes are formed.

(i) Suggest why two of these enzymes, **S** and **T**, are needed at Stage D.

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(ii) Suggest how enzyme **U** might catalyse the breakdown of the host cell membrane at Stage E.

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(Total for Question = 11 marks)

Q10. Eating food that is contaminated with microorganisms can cause food poisoning.

(a) Not all contaminated food causes food poisoning. Suggest explanations for this.

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(b) The norovirus causes a type of food poisoning, commonly called stomach flu. Norovirus is a non-enveloped RNA virus.

The virus stays in the small intestine and causes symptoms approximately 24 hours after eating the contaminated food.

Stomach flu can be caused by eating food containing as few as 20 viral particles.

(i) Suggest how new viral particles are formed inside the host cells.

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(ii) Suggest why so few viral particles are enough to cause symptoms after 24 hours.

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(iii) The risk of transmitting food poisoning microorganisms can often be reduced by using alcohol-based handwashes.

Suggest why alcohol-based handwashes do **not** reduce transmission of the norovirus.

(2)

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(Total for Question = 11 marks)

Mark Scheme

Q1.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to three of the following • the bacteria are inside {macrophages /phagocytes} (1) • this bacterium has a (thick) waxy cell wall (1) • lysosomes cannot fuse with phagocytic vacuole / bacteria not destroyed by enzymes (1) • bacteria within tubercles (cannot be destroyed) (1)	ALLOW waxy coat	Expert (3)

Q2.

Question Number	Answer	Additional Guidance	Mark
(i)	A description that makes reference to three of the following: • heat to 90-98°C { to break hydrogen bonds between (DNA) strands / separate the strands of DNA } (1) • { joining of primers / annealing } at 50- 75°C (1) • { elongating / extension / addition of nucleotides } / DNA polymerase involved in formation of phosphodiester bonds (1) • to double the quantity (of the DNA) (1)	ALLOW heating to 90-98°C to break hydrogen bonds or to unzip DNA or to denature the DNA ALLOW 'binding/aligning' for joining ALLOW description of production of complementary strands of DNA ALLOW taq polymerase ALLOW replication for doubling	(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	• calculation correct • correct answer provided (1)	<u>Example of calculation</u> 2^{20} 1 048 576 (> 1 000 000) or 1.05×10^6 Correct answer without working scores full marks	(2)

Q3.

Question Number	Answer	Additional Guidance	Mark																					
(i)	An answer that makes reference to the following: • correct ranking for both columns (1) • correct difference in rank (1) • correct difference squared (1)	<table><tr><td>E</td><td>48.8</td><td>4</td><td>23.6</td><td>4</td><td>0</td><td>0</td></tr><tr><td>F</td><td>50.1</td><td>7</td><td>24.2</td><td>5</td><td>2</td><td>4</td></tr><tr><td>G</td><td>49.2</td><td>6</td><td>23.1</td><td>2</td><td>4</td><td>16</td></tr></table> -2 and -4 are incorrect differences in rank	E	48.8	4	23.6	4	0	0	F	50.1	7	24.2	5	2	4	G	49.2	6	23.1	2	4	16	(3)
E	48.8	4	23.6	4	0	0																		
F	50.1	7	24.2	5	2	4																		
G	49.2	6	23.1	2	4	16																		

Question Number	Answer	Additional Guidance	Mark
(ii)	• numerator (top line of formula) correctly calculated (1) • denominator (bottom line of formula) correctly calculated (1) • correct answer (1)	Example of calculation 6 x 34 or 204 7 x 48 or 336 0.3929 / 0.393 / 0.39 Correct answer with no working scores full marks	(3)

Question Number	Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to the following: • no (significant) correlation (1) • as the calculated figure is less than { 0.786 / the critical value for $p=0.05$ } (1)	ALLOW not statistically significant ECF - ALLOW significant correlation if the value calculated for $3a_{ii}$ is greater than { cv for 0.05 / 0.786 } ALLOW 5% FOR 0.05 ECF- ALLOW calculated value is greater than the cv if the value calculated for $3a_{ii}$ is greater than 0.786	(2)

Q4.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following: • measure temperature from { several readings / random positions } (within the group of larvae) (1) • description of how mean calculated (1)	ALLOW stated number of measurements e.g. readings summated and answer divided by number of readings taken ALLOW 'average' for mean	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following: - increases enzyme activity for (larvae / species F) (1) - high temperature { kills / denatures enzymes of } other species (1) (high temperature) increases food availability by { reducing competition from other species / increasing rate of decomposition of rhino } (1)	ALLOW description of increase in activity including maximizes rate of growth/digestion, shorter lifecycle IGNORE ref to metabolic activity unqualified ALLOW outcompetes other {species / larvae} for food	(3)

Q5.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to the following: - increasing dose of interferon increases the survival time of the mice - because interferon inhibits viral replication (inside cells) - the greater the dose of interferon the fewer virus particles {produced / released} (to infect other cells)	ALLOW positive correlation between interferon dose and survival time ALLOW interferon prevents virus infecting other cells	(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to two of the following: • bacteria do not possess {rER / Golgi apparatus} • polypeptide chain is not {processed / modified} properly • therefore the protein is {incorrectly folded / carbohydrate is not added}	ALLOW converse statements for each marking point ALLOW Golgi body ALLOW protein ALLOW is not glycosylated	(2)

Question Number	Answer	Mark
(iii)	B - exocytosis <i>The only correct answer is B</i> <i>A is not correct because endocytosis is the process used to take particles into cells</i> <i>C is not correct because facilitated diffusion is not used to transport proteins</i> <i>D is not correct because phagocytosis is a process used to engulf large particles such as bacteria</i>	(1)

Q6.

Question Number	Answer	Additional Guidance	Mark
(i)	Correct answer gains all 3 marks 1. line drawn between 25°C (core) and 15°C (ambient) ; 2. line drawn from centre of circle through the intersect of line 1 with diagonal ; 3. time of death = {23 - 24} ;	1 ACCEPT within the next scale line 2 CE applies 3 CE applies	(3)

Question Number	Answer	Additional Guidance	Mark
* (ii)	(QWC – Spelling of technical terms must be correct and the answer must be	QWC emphasis is clarity of expression	

Question Number	Answer	Additional Guidance	Mark
(a)(i)	1. levels of antibody rise sooner after infection / eq ; 2. levels of antibody rise faster after infection / eq ; 3. levels of antibody rise higher after infection / eq ; 4. credit comparative manipulation of data ;	do not piece together ACCEPT converse for mps 1, 2 and 3 in context of vaccination 4. e.g. increase after infection is {10 (au) more / 1.83 times more} peak after infection is 13 (au) higher rate of increase after infection is 1.27 au day⁻¹ faster	(2)

Question Number	Answer	Additional Guidance	Mark
(a)(ii)	1. secondary (immune) response ; 2. reference to memory cells ; 3. idea that (on infection / second exposure) memory cells are {activated / cloned / stimulated / eq}; 4. idea that (in secondary response) antibodies are released from plasma cells ;	1. ACCEPT secondary immunity 3. ACCEPT B memory cells differentiate into plasma cells	(3)

Question Number	Answer	Additional Guidance	Mark
(b)(i)	1. idea that antibodies will only be present if antigen present ; 2. idea that antigen B is not present in vaccine ; 3. vaccination failed to stimulate immune response / eq ;		(2)

Question Number	Answer	Mark
(b)(ii)	C natural active	(1)

Question Number	Answer	Additional Guidance	Mark
(c)	1. idea that {a comment cannot be made / caution in interpreting results should be taken / eq} ; 2. no indication of number of rats used / eq ; 3. no data points / eq ; 4. no error bars (on graph) / no indication of variability / eq ; 5. no statistical evidence / eq ; 6. idea that no indication of {experimental details / control variables / control group / eq} ; 7. idea that mean has been used therefore there must have been some repeats / eq ;	1. IGNORE not reliable or is reliable 2. IGNORE no repeats / sample was small ACCEPT number of repeats not known / sample size not known	(3)

Q8.

Question Number	Answer	Mark
(i)	The only correct answer is A artificial active immunity <i>B is incorrect because the immunity is not passive</i> <i>C is incorrect because the immunity is not natural</i> <i>D is incorrect because the immunity is not natural or passive</i>	(1)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to three of the following • T helper cells bind to { protein / antigen } the APC (1) • (therefore) leading to the production of {active T helper cells / T memory cells} (1) • the T helper cells activate the B cells to { divide / become } cells capable of producing antibodies (1) • The memory cells remain in the body so antibodies can be produced quickly (on re-infection)(1)	ALLOW B cells develop into B effector cells or plasma cells	(3)

Q9.

Question Number	Answer	Additional Guidance	Mark
(a)(i)	1. {skin / epidermis} is a barrier / eq ; 2. reference to keratin ; 3. reference to lack of receptors (for the virus) ;	Accept prevents entry but not prevents infection NB keratin in skin forms a barrier = 2 marks Accept skin has different receptors	(2)

Question Number	Answer	Additional Guidance	Mark
(a)(ii)	1. idea that viruses only {infect / attach to / eq} {specific receptors / specific cells / host cells} ; 2. idea that receptors not present on {blood cells / endothelial cells / eq} ; 3. reference to {destruction / eq} of viruses by phagocytes ;	Accept white blood cells. neutrophils; PMN Ignore macrophages Not lymphocytes, T cells, plasma cells	(2)

Question Number	Answer	Additional Guidance	Mark
(b)	- reverse transcriptase (required) in HIV, no reverse transcriptase in cold virus ; - DNA formed (using RNA) in HIV, {no DNA formed / RNA used to make protein / translation} in cold virus ; - reference to {provirus / latency / delay in virus formation / eq} in HIV infection, {no provirus / lytic cycle / (immediate) formation of virus particles / eq} in cold virus ;	NB answers can be pieced together but candidates still have to state both parts of mark point	(2)

Question Number	Answer	Additional Guidance	Mark
(c)(i)	- to synthesise (common cold) RNA / eq ; - for amino acids to bind to tRNA / eq ; - to synthesise (common cold) protein (capsid) / eq ;	Accept translation	(2)

Question Number	Answer	Additional Guidance	Mark
(c)(ii)	- idea of enzyme affecting {molecules in membrane / proteins / (phospho)lipids / cholesterol} ; - enzyme breaks {bonds / named bonds / eq} ; - reference to {(by) hydrolysis / hydrolytic enzymes} ; - credit detail of enzyme action ; - reference to enzyme U as {protease / lipase / cholesterase} ;	eg lowers activation energy, binding of active site to substrate (cannot credit reference to catalyst, as in stem of question) Ignore lysosyme	(3)

Q10.

Question Number	Answer	Additional Guidance	Mark
(a)	- reference to enzymes {killing / destroying / eq} (microorganisms) ; - reference to {stomach acid / hydrochloric acid / HCl} {killing / destroying / eq} (microorganisms) ; - reference to lack of oxygen affecting (microorganisms) ; - idea of competition by gut flora with (microorganisms) ; - idea that insufficient numbers of (microorganisms) (to cause food poisoning) ; - idea that the (microorganisms) may not be {pathogenic/ harmful / cause food poisoning} ; - reference to (immediate) vomiting to remove (microorganisms) ;	Accept lysozymes / enzymes in saliva Accept enzymes destroying viruses Accept acid destroying viruses Not viruses Not viruses Not pathogens	(3)

Question Number	Answer	Additional Guidance	Mark
(b)(i)	- reference to synthesis of RNA ; - using host cell {enzymes / named enzyme / (RNA) nucleotides} ; - reference to synthesis of (viral) proteins ; - using host cell {enzymes / named enzyme / amino acids / ribosomes / tRNA / ATP} ; - reference to assembly of {viruses / particles} (inside cells) ;	Accept mRNA Not reverse transcriptase Accept protein and RNA {form / make / eq} {viruses / particles}	(4)

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	1. idea of a delay (up to 24 hours) whilst viral particles are replicating / eq ; 2. idea that a virus can {result in many particles being formed / replicate very fast} ; 3. idea that more host cells infected ;	2. Accept reference to lytic cycle	(2)
Question Number	Answer	Additional Guidance	Mark
(b)(iii)	1. reference to the {hand wash / alcohol} not affecting the virus ; 2. reference to (noro) virus {not having an envelope / surrounded by protein / eq} ; 3. alcohol does not {damage protein coat / penetrate} virus / eq ; 4. protein is hydrophilic / alcohol is an organic solvent / eq ;	1. Not does not kill virus 2. Accept surrounded by a capsid	(2)

Q1.

The scientific article you have studied is from *Scientific American*.

Use the information from the scientific article and your own knowledge to answer the following question.

The protein $\alpha 4\beta 1$ integrin projects out from the cell surface membrane of white blood cells.

Deduce how molecules such as $\alpha 4\beta 1$ integrin help immune cells cross the blood-brain barrier (paragraph 8).

(2)

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(Total for question = 2 marks)

Q2.

Blood clotting is a process that is affected by genes.

Some people are at an increased risk of a condition called deep vein thrombosis (DVT).
Blood clots form in the veins of people with DVT.

There are two alleles in a population, a wild type allele and G20210A.

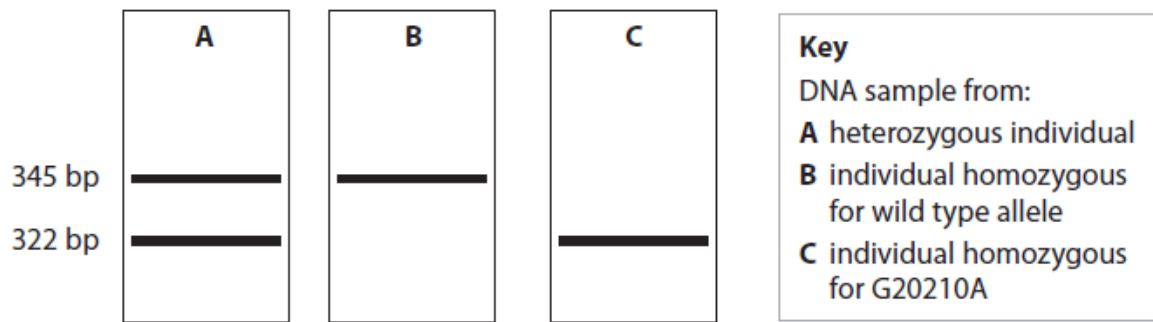
Individuals with a family history of DVT may be offered a genetic test for the G20210A allele.

In this test, a sequence of 345 base pairs (bp) from this gene is amplified using the polymerase chain reaction (PCR).

A specific restriction enzyme is then added to the amplified DNA.

The DNA fragments produced are then separated using gel electrophoresis.

The diagram shows the results of gel electrophoresis for three individuals, A, B and C.



(i) Explain the role of DNA primers in the production of the amplified 345bp sequence.

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(ii) Explain why the amplified DNA fragments for the G20210A allele and the wild type allele are different.

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(iii) Devise an investigation to determine the optimum number of cycles for the polymerase chain reaction used to amplify the DNA for this test.

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(Total for question = 9 marks)

Q3.

The structure of the cell surface membrane can be explained using the fluid mosaic model.

This model suggests that there are a variety of different proteins and glycoproteins present in a phospholipid bilayer.

* The ratio of lipid to protein in a cell surface membrane is approximately 1:1.

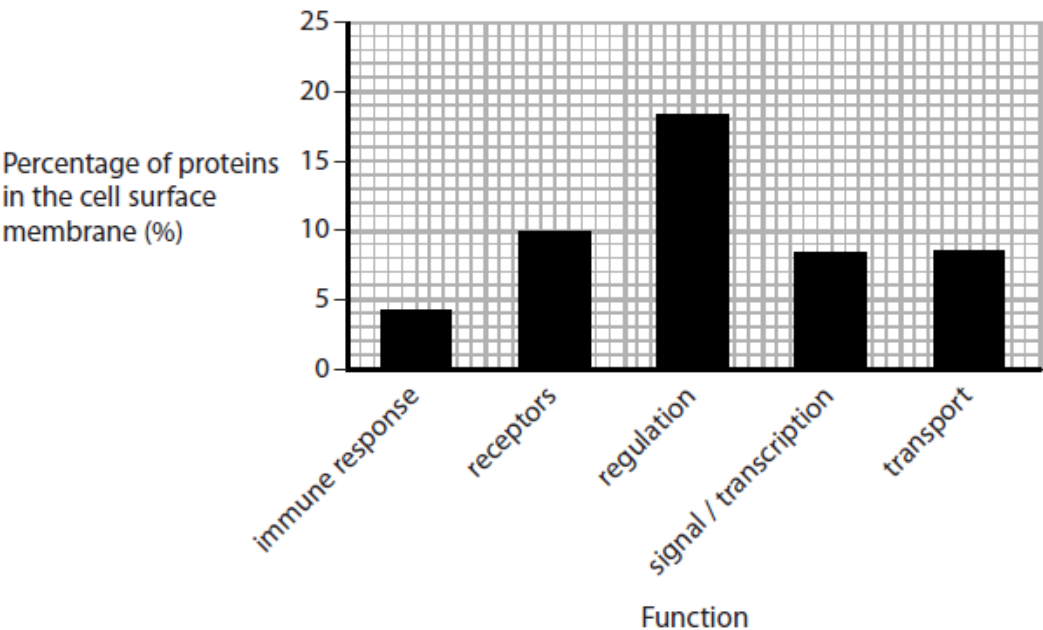
Scientists have studied the proteins present within human cells. Proteins in a cell are found in several locations.

The table shows the percentage of protein found in some locations in a cell.

Location within a cell	Percentage of total protein present (%)
cell surface membrane	68.2
cytoplasm	1.4
endoplasmic reticulum / Golgi apparatus	1.4
nucleus	14.5
other	14.5

The proteins within the cell surface membrane were further analysed for their function.

The graph shows some of the results of this analysis.



Analyse the data to evaluate the following statement.

'The variety of different proteins present in the cell surface membrane makes them more important than the phospholipid bilayer to the functioning of that cell.'

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(Total for question = 9 marks)

Q4.

Tuberculosis (TB) is an infectious disease caused by mycobacteria.

Individuals infected with M. tuberculosis can be treated with antibiotics.

Four of the antibiotics used to treat TB are shown in the table.

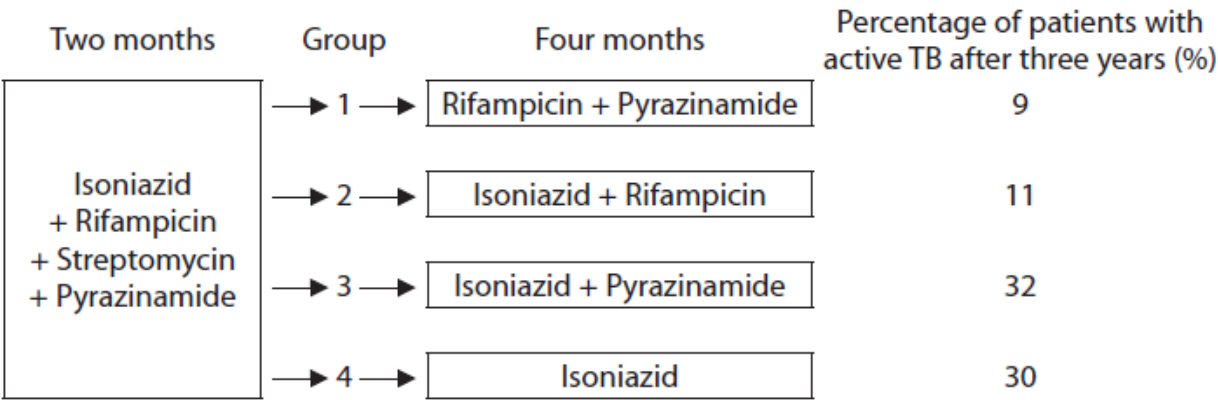
Antibiotic	Mechanism of action
Isoniazid	Inhibits the synthesis of a fatty acid needed to make bacterial cell walls
Rifampicin	Inhibits bacterial RNA polymerase
Streptomycin	Binds to bacterial ribosomes to prevent the binding of tRNA
Pyrazinamide	Not yet known, but not the same mechanisms as the other three antibiotics

In one clinical trial lasting six months, the effect of treating TB with these antibiotics was investigated.

All patients were treated with all four antibiotics for two months. Then they were treated with different pairs of antibiotics or isoniazid alone for a further four months.

All patients were free of any signs of active TB at the end of the clinical trial.

The design of the trial and the percentage of these patients with TB three years after the trial ended are shown in the diagram.



Analyse the data to comment on the effectiveness of these antibiotics for the treatment of TB.

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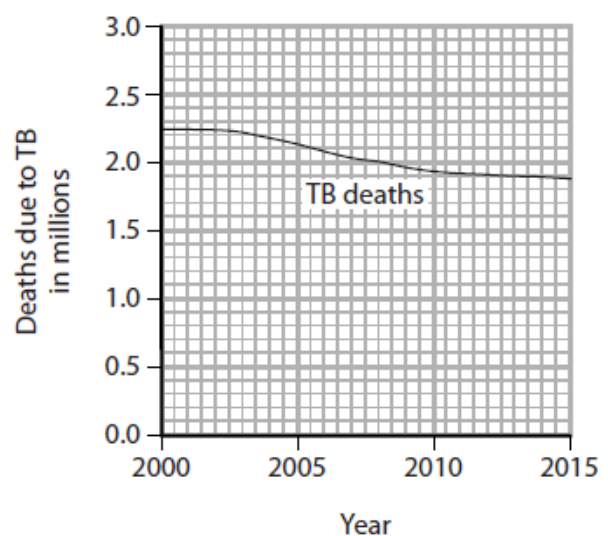
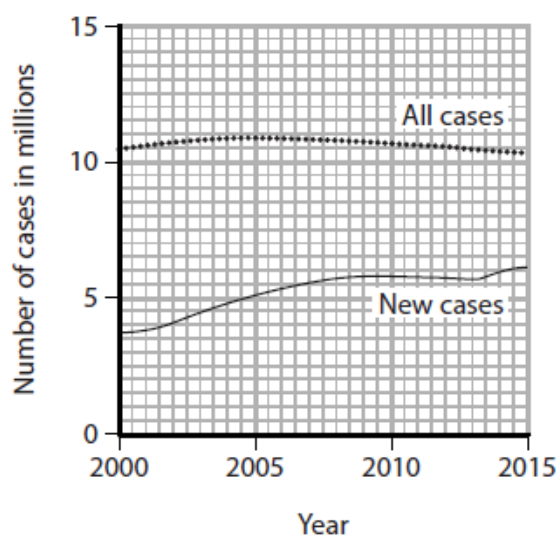
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(Total for question = 6 marks)

Q5.

Tuberculosis (TB) is an infectious disease caused by mycobacteria.

The graphs show the number of cases of TB and the number of deaths from TB worldwide from 2000 to 2015.



In 1993 the World Health Organisation (WHO) declared TB a global public health emergency. Since then, there has been a programme to reduce the impact of this disease.

Analyse the data to deduce the effectiveness of this programme.

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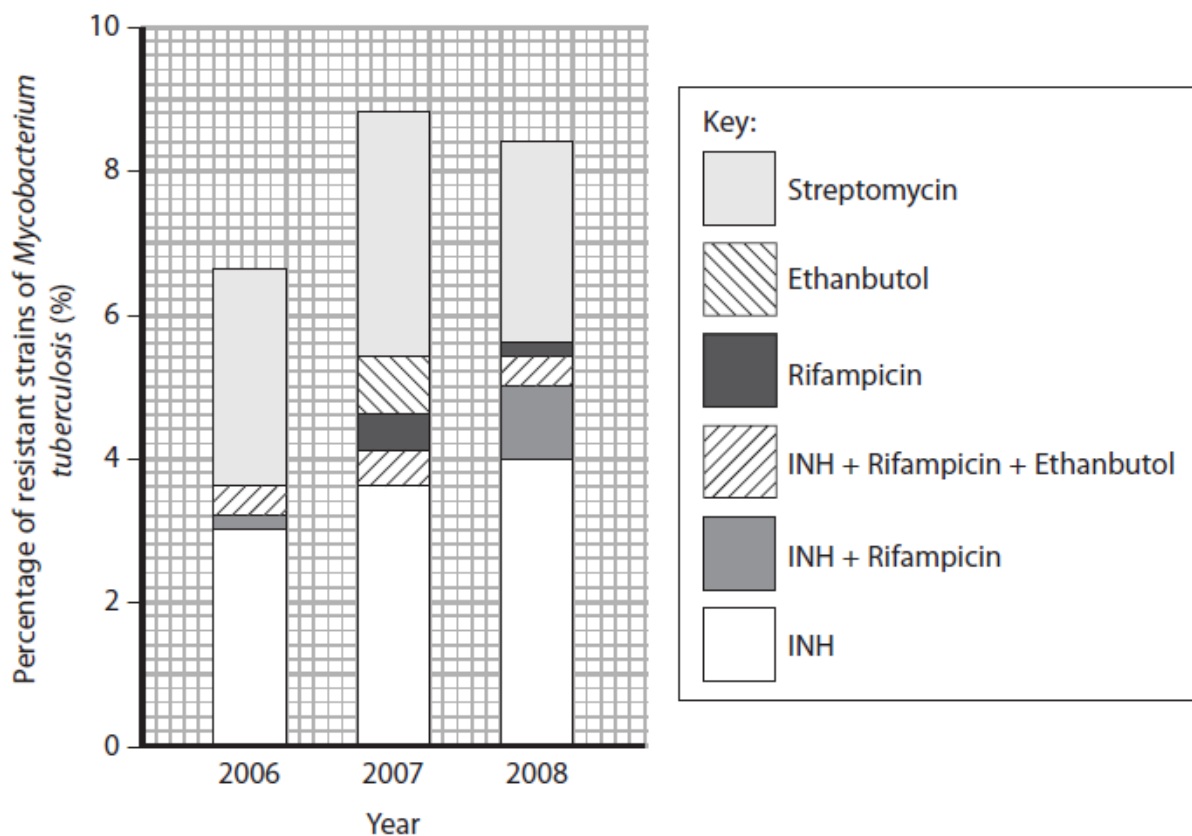
(Total for question = 3 marks)

Q6.

Treating *Mycobacterium tuberculosis* infections can be a problem, as the bacteria are resistant to many antibiotics.

There are many strains of *Mycobacterium tuberculosis*. Different strains are resistant to different antibiotics or combinations of antibiotics.

The chart below shows the percentage of resistant strains of *Mycobacterium tuberculosis* to six different antibiotics, or combinations of antibiotics, in 2006, 2007 and 2008.



(i) Using the information in the graph, compare the types of antibiotics and combinations of antibiotics that the *Mycobacterium tuberculosis* are resistant to in 2006 with 2007.

(3)

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(ii) The percentage of strains of *Mycobacterium tuberculosis* resistant to the antibiotic INH has increased during these three years.

Suggest how natural selection could have resulted in this increase.

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(iii) Suggest how hospitals could prevent an increase in the percentage of strains of *Mycobacterium tuberculosis* resistant to antibiotics.

(2)

Q7.

Antibiotics are used in the treatment of bacterial infections.

(a) (i) Cephalosporins are antibiotics that inhibit the production of bacterial cell walls.

Suggest why cephalosporins are **bactericidal** antibiotics.

(2)

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(ii) Quinolones are antibiotics that inhibit the synthesis of DNA in bacterial cells.

Suggest why quinolones are **bacteriostatic** antibiotics.

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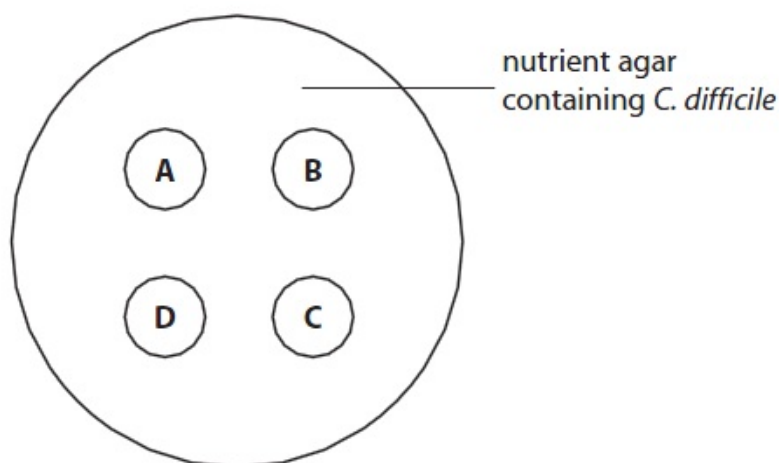
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(b) An investigation of the effectiveness of different antibiotics on *Clostridium difficile* was carried out by a hospital laboratory. Several nutrient agar plates, containing *C. difficile*, were prepared.

Four discs, A, B, C and D, were placed on the surface of each plate. Each disc contained the same concentration of a different antibiotic.

The diagram below shows the position of the four discs on each agar plate, before being incubated.



After incubation, the scientists in the laboratory concluded that *C. difficile* was completely resistant to antibiotics A and C. They also concluded that antibiotic D was more effective against *C. difficile* than antibiotic B.

(i) Explain how the appearance of the nutrient agar plates, after incubation, would have enabled the scientists to reach these conclusions.

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For each of the statements below, put a cross (☒) in the box next to the term that completes each statement.

(ii) In this investigation, several nutrient agar plates were used for

(1)

☒ **A** accuracy

☐ **B** precision

☐ **C** reliability

☐ **D** validity

(iii) In this investigation, each disc had the same concentration of antibiotic for

(1)

☐ **A** accuracy

☐ **B** precision

☐ **C** reliability

☐ **D** validity

(c) Hospital-acquired infections caused by bacteria can be a major problem for patients.

In a study in a London hospital, it was found that pillows contaminated with bacteria could spread infections between patients.

Suggest how this hospital could improve the prevention and control of the spread of infections.

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(Total for question = 12 marks)

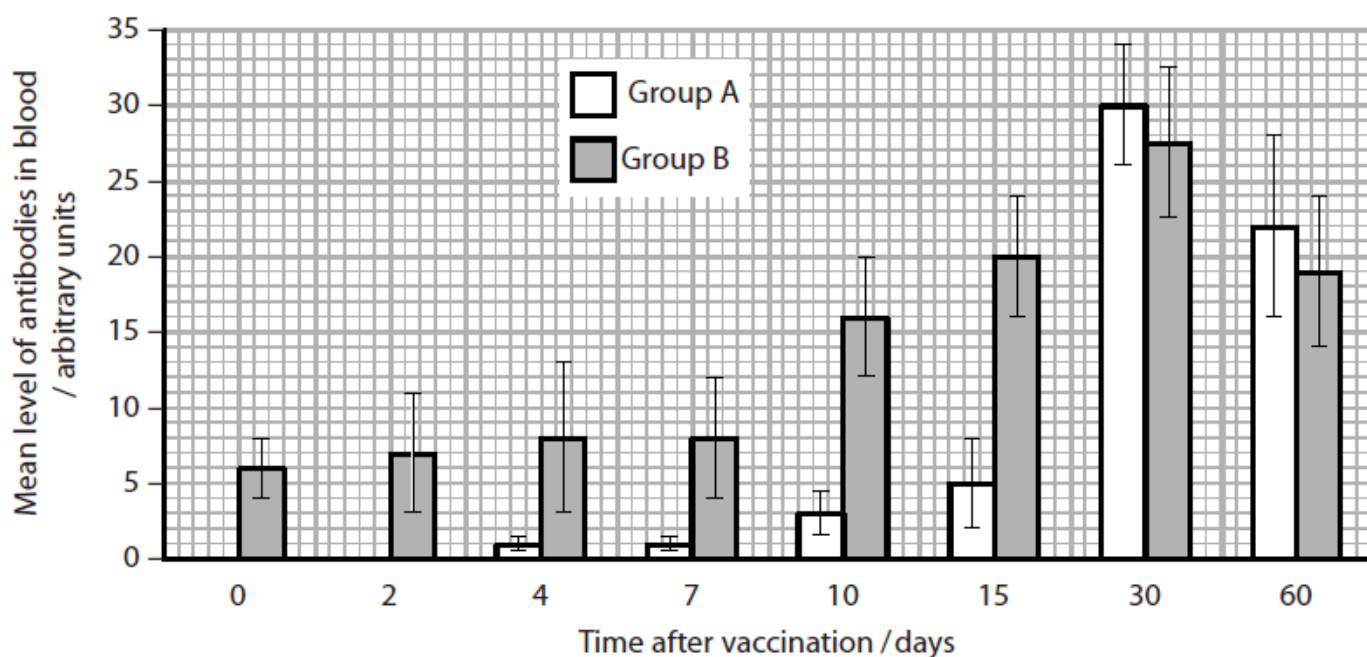
Q8.

Yellow fever is caused by a virus. Infection with this virus causes thousands of deaths every year in people who have not been vaccinated.

The graph below shows the mean levels of antibodies in the blood of two groups of people, group A and group B, after being vaccinated. The same vaccine was used each time.

Group A consisted of eight people. They were given a vaccination against yellow fever and their blood was analysed.

Group B consisted of nine people who had already been vaccinated against yellow fever. They were given a second vaccination and their blood was analysed.



(a) Place a cross ☒ in the box next to the term that describes the type of immunity that results from this vaccination against yellow fever.

(1)

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

(b) (i) Compare the changes in the mean levels of antibodies in these two groups of people in the first fifteen days after vaccination.

(2)

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(ii) Explain why the mean levels of antibody in group B are different from group A in the first fifteen days.

(3)

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(c) Using the information in the graph, explain the advantage of vaccinating people twice against yellow fever.

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(d) Comment on the reliability of the data shown in the graph.

(3)

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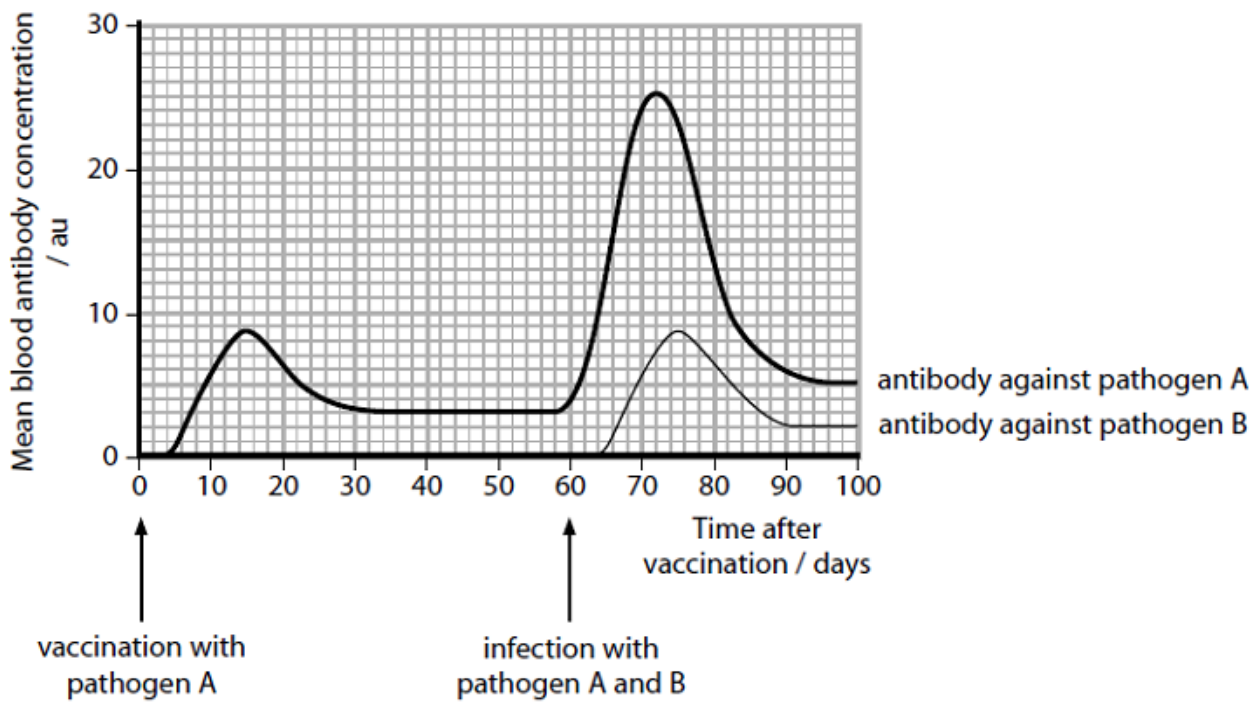
(Total for question = 11 marks)

Q9.

Many people have a vaccination before visiting some countries for the first time.

A person was vaccinated with a weakened form of pathogen six weeks before travelling to a particular country. The person was infected by two different pathogens, A and B, when in this country.

The graph shows what happened to different blood antibody concentrations of the person after vaccination and after infection by the two different pathogens.



(a) The changes to blood antibody concentration occur because vaccination produces

(1)

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

*(b) Explain why this person did not become ill from pathogen A but did become ill from pathogen B when visiting this country.

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(Total for question = 7 marks)

Q10.

The scientific article you have studied is from *Scientific American*.

Use the information from the scientific article and your own knowledge to answer the following question.

'The lymphatic vessels also ferry antigens—substances capable of inducing an immune response—from the tissues into tissue-draining lymph nodes, where they are presented to immune cells' (paragraph 15).

Describe how these antigens are presented to immune cells.

(3)

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(Total for question = 3 marks)

Q11.

Humans are surrounded by microorganisms in the air, water and food.
 Some microorganisms are pathogenic.
 The human body has several barriers to prevent infection by pathogens.

Complete the table by putting a tick (✓) in the box if the type of barrier is correct.
 If the type of barrier is not correct, place a cross (✗) in the box.

(2)

Type of barrier	Keratin in the skin	Lysozyme in mucus	Hydrochloric acid in the stomach
Physical			
Chemical			

(Total for question = 2 marks)

Q12. Human diseases can be caused by many different types of organism, such as bacteria and viruses.

(a) Give **two** differences between the genetic material of bacteria and viruses.

(2)

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(b) Tuberculosis (TB) is caused when droplets, containing the bacterium *Mycobacterium tuberculosis*, are inhaled into the lungs.

In the lungs, large numbers of the bacterium are formed rapidly. These can be ingested by macrophages. Eventually, tubercles (tissue masses), containing dormant bacteria inside macrophages, may form.

(i) Describe how macrophages ingest the bacteria.

(2)

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(ii) Suggest why treatment with antibiotics may not be effective against the dormant bacteria in the tubercles.

(2)

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(iii) TB can be prevented by vaccination. Explain how a person can develop artificial active immunity following vaccination.

(3)

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(c) In a person with TB, the dormant bacteria in tubercles may be activated after several years. The bacteria multiply rapidly, resulting in severe lung damage.

The bacteria are released from the tubercles. These bacteria can inhibit the activity of T cells and infect other organs.

Explain why the activity of these bacteria and the inhibition of T cells means that a person may quickly develop severe symptoms leading to death.

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(Total for Question = 13 marks)

Q13.

Ebola virus disease (EVD) is a rare and deadly disease most commonly found in Africa. Following a severe outbreak in 2014, in which 11 000 people died, work has been underway to develop a vaccine.

The vaccine is still undergoing clinical trials, but was given approval for use in recent Ebola outbreaks.

(i) Describe how clinical trials of a vaccine would be conducted.

(3)

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(ii) The Ebola vaccine was given to health workers and immediate family of those with the disease.

Justify the use of this vaccine, even though the clinical trials had not been completed.

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(Total for question = 7 marks)

Q14.

The scientific article you have studied is adapted from several sources.

Use the information from the scientific article and your own knowledge to answer the following questions.

Compare and contrast the structure of a bacterium, such as the one that causes neurological syphilis, with the Human Immunodeficiency Virus (HIV) (paragraph 49).

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(Total for question = 3 marks)

Q15.

The scientific article you have studied is adapted from an article from '*The Scientist*'.

Use the information from the scientific article and your own knowledge to answer the following questions.

Bacillus subtilis 'initiate a hibernation protocol' (paragraph 25).

Mycobacterium tuberculosis can also become dormant for long periods of time.

Compare and contrast the dormancy of these two species of bacteria.

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(Total for question = 4 marks)

Q16.

Tuberculosis (TB) is an infectious disease caused by mycobacteria.

Most cases of TB are caused by infection with *Mycobacterium tuberculosis* (*M. tuberculosis*).

The ribosomes of bacteria are

(1)

- ☐ **A** larger than the ribosomes in eukaryotes
- ☐ **B** smaller than ribosomes in eukaryotes
- ☐ **C** the same size as ribosomes in animal cells
- ☐ **D** the same size as ribosomes in plant cells

(Total for question = 1 mark)

Q17.

The scientific article you have studied is adapted from an article from '*The Scientist*'.

Use the information from the scientific article and your own knowledge to answer the following questions.

Give reasons why 'humble microbes', such as bacteria, are considered less complex than

eukaryotes (paragraph 4).

(2)

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(Total for question = 2 marks)

Q18.

The coffee husks, shown in the photograph, are a waste product of coffee plantations.

Composting has been suggested as an environmentally friendly way of decomposing these coffee husks.



The effect of adding cow dung to coffee husks, before they are composted, has been investigated.

The table shows the percentages of organic carbon and nitrogen in two compost heaps at the start of composting and after 90 days.

	Husks alone		Husks with added cow dung	
Days composting	0	90	0	90
Organic carbon (%)	54.50	41.70	48.10	35.40
Nitrogen (%)	1.84	2.31	2.76	3.19

Comment on the effect of adding cow dung to composting coffee husks.

(3)

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(Total for question = 3 marks)

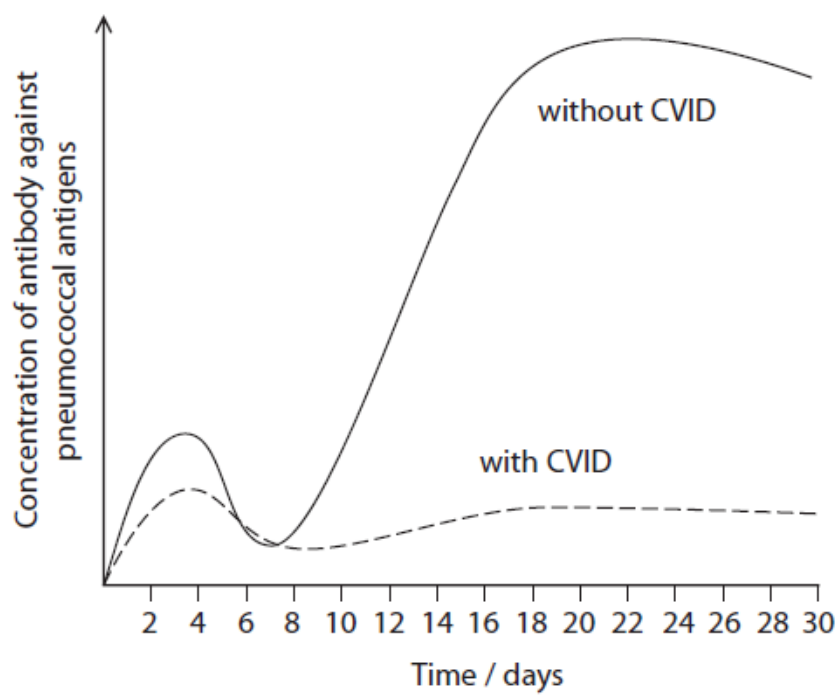
Q19.

Common variable immunodeficiency (CVID) is one of the most commonly diagnosed immunodeficiency disorders.

The infection history of a group of individuals with CVID is summarised in the table.

Type of infection	Characteristics of infection	
	Frequency of infection	Severity of infection
Bacterial	Much more frequent than expected	Effects of infection are more serious than in the general population
Viral	Slightly higher frequency than expected	Effects of infection are comparable to infection in the general population

The average antibody response of two groups, following immunisation with a bacterial pneumococcal vaccine, is shown in the graph.



The distribution of lymphocytes in the blood for the two groups is shown in the table.

Group	Percentage of white blood cells (%)		T helper cell : T killer cell ratio
	B lymphocytes	T lymphocytes	
With CVID	8	78	1.7 : 1
Without CVID	14	80	1.5 : 1

Analyse the data to evaluate how the immunological defect in the group with CVID might be treated.

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(Total for question = 6 marks)

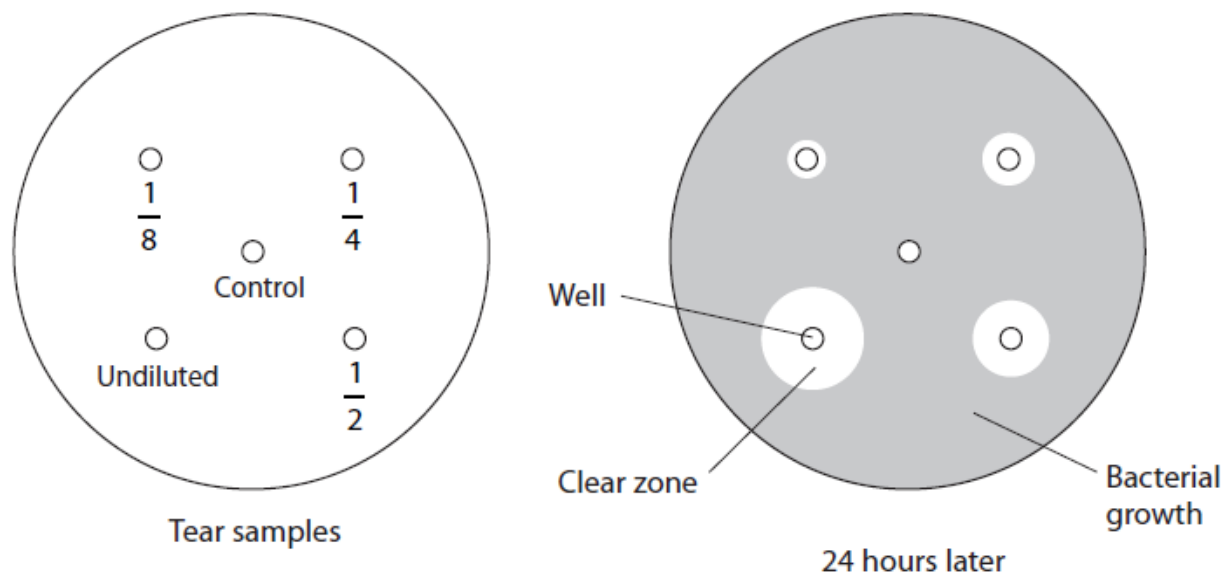
Q20.

Lysozyme is one component of the non-specific response to infection.

A student investigated the activity of lysozyme in tears.

A suspension of bacteria was mixed with molten agar and poured into a Petri dish. After the agar had solidified, wells were cut and different dilutions of tear sample were placed in the wells.

After 24 hours the Petri dish was inspected.



(i) State the relationship between lysozyme dilution and the size of the clear zone.

(1)

(ii) Calculate the area of the clear zone for the undiluted tear sample.

(Area of a circle = πr^2)

(2)

Q21.

Bacteria are involved in the decomposition of organic matter.

(a) Place a cross ☒ in the box next to the type of chemical reaction that takes place in decomposition.

(1)

☒ **A** condensation

☒ **B** esterification

☒ **C** hydrolysis

☒ **D** polymerisation

(b) An investigation was carried out to study the rate of decomposition of leaves from ash trees

and beech trees.

Five piles of each type of leaf were placed outside on the ground and each pile was covered with a heavy bucket. Each pile of leaves had a mass of 10 grams.

Every few weeks, one pile of each type of leaf was removed and weighed.

The table below shows the results of this investigation.

Time after falling from the tree / weeks	Mass of pile of ash leaves / g	Mass of pile of beech leaves / g
0	10.0	10.0
4	4.9	9.1
8	2.0	8.4
16	1.1	6.0
32	1.2	2.8
64	0.8	2.4

(i) Place a cross ☒ in the box next to the reason for using five piles of ash leaves in this investigation.

(1)

- ☒ **A** to calculate a mean
- ☒ **B** to give a range of values for the independent variable
- ☒ **C** to make the investigation valid
- ☒ **D** to produce reliable data

(ii) A student made the following conclusions from these results.

Decomposition of beech leaves is faster than ash leaves.

Bacteria are needed for the decomposition of beech and ash leaves.

There is a correlation between decomposition and time.

Place a cross ☒ in the box next to the number of correct conclusions made by this student.

(1)

- ☒ **A** none
- ☒ **B** one
- ☒ **C** two
- ☒ **D** three

(iii) Explain why there is a decrease in mass of the leaves.

(4)

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(iv) Suggest what effect an increase in temperature would have on the rate of decomposition of these leaves. Give an explanation for your answer.

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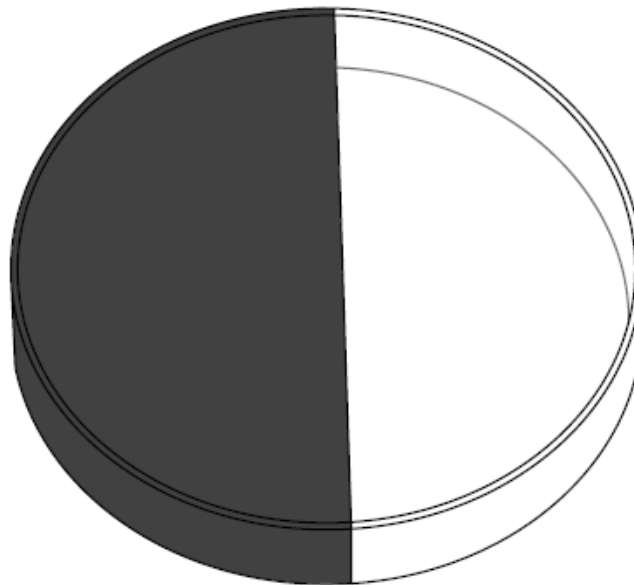
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(Total for question = 11 marks)

Q22.

Blowfly larvae can be used by a forensic scientist to help determine the time of death of a body.

The diagram shows a Petri dish used by a student to investigate whether young and old blowfly larvae show a preference for light or dark conditions.



In the first trial, the left side was dark and the right side was light.

Five blowfly larvae were added to each side of the chamber.

After five minutes, the number of larvae on each side of the Petri dish was recorded.

In the second trial, the same experiment was repeated but this time the right side was dark and the left side was light.

The table shows the results of the trials.

Trial	Number of young blowfly larvae		Number of old blowfly larvae	
	Left side dark	Right side light	Left side dark	Right side light
1	9	1	2	8
2	2	8	9	1

(a) Give a null hypothesis for this investigation.

(1)

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(b) The Chi squared test can be used to determine whether the results of this investigation indicate a significant difference in the distribution of young larvae between the light and the dark side.

(i) Use the formula to calculate the Chi-squared value for young larvae.

(3)

$$\chi^2 = \sum \frac{(\text{Observed} - \text{Expected})^2}{\text{Expected}}$$

Answer

(ii) The table below gives some critical values for Chi-squared.

p value			
0.15	0.1	0.05	0.025
2.07	2.71	3.84	5.02

Use your calculated value to determine whether the difference between the observed and expected results is significant.

(1)

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(c) Forensic scientists measure the length of larvae found in the tissues of a dead person to help them determine time of death. Older larvae are longer than younger larvae.

The growth of insect larvae can be affected by a number of factors including toxins.

Explain a procedure that you could use to find out if the presence of a toxin in a sample of dead tissue could affect the accuracy of estimating time of death.

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(Total for question = 10 marks)

Q23.

The decomposition of leaves depends on the content of the leaves, the presence of certain microorganisms and a number of abiotic factors.

Leaves consist of a number of organic molecules, including lignin and cellulose.

(a) Place a cross ☐ in the box next to the groups of microorganisms that all cause decomposition.

(1)

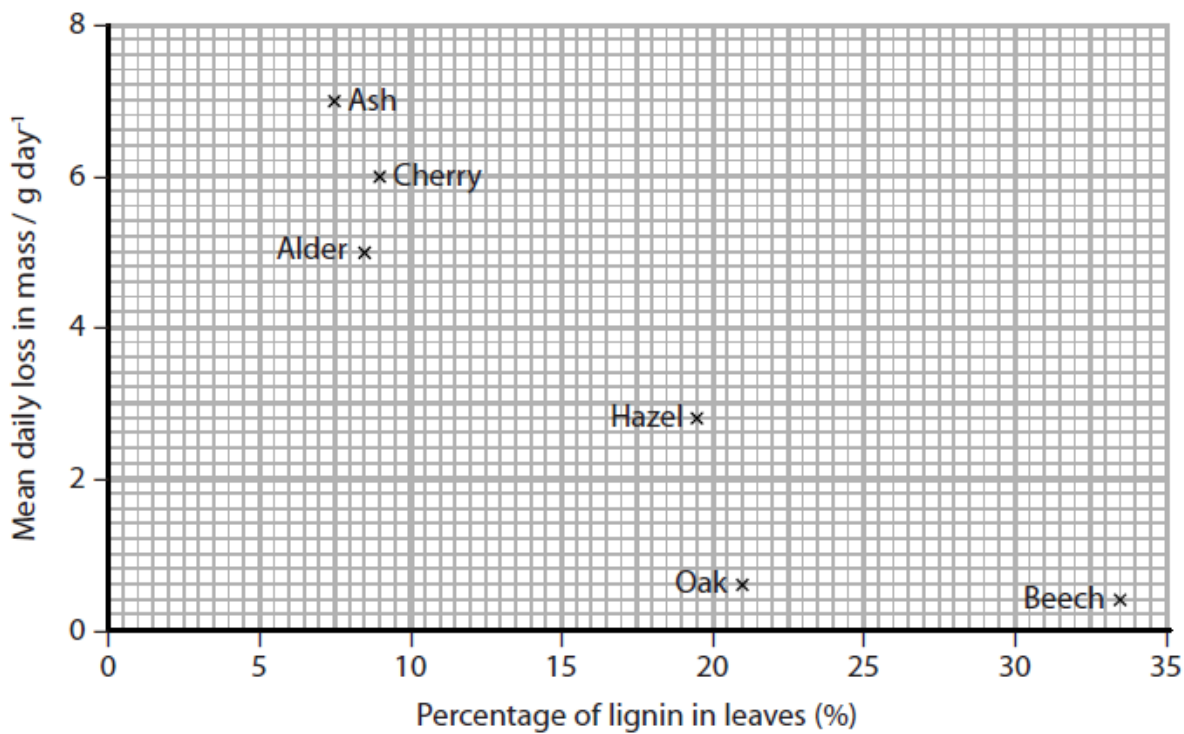
- ☐ **A** bacteria and fungi
- ☐ **B** bacteria and viruses
- ☐ **C** fungi and viruses
- ☐ **D** bacteria, fungi and viruses

(b) An investigation was carried out into the effect of lignin content on the decomposition of leaves from different types of tree.

The lignin content of leaves from an ash tree was determined. A pile of ash leaves was collected and weighed. The leaves were left for 40 days and reweighed. The mean daily loss in mass was calculated.

This was repeated for leaves from five other species of tree. All six piles of leaves had the same starting mass.

The results of this investigation are shown in the graph below.



(i) A student made the following conclusions from the data.

Beech leaves decompose faster than cherry leaves.

Microorganisms are needed for the decomposition of these leaves.

There is a causal relationship between lignin content and decomposition.

Place a cross ☒ in the box next to the number of correct conclusions made by the student.

(1)

- ☒ **A** none
- ☐ **B** one
- ☐ **C** two
- ☐ **D** three

(ii) Place a cross ☒ in the box next to the term that completes the following statement.

Each pile of leaves had the same mass to ensure the investigation was

(1)

- ☒ **A** accurate
- ☐ **B** precise
- ☐ **C** reliable
- ☐ **D** valid

(iii) Suggest what happens to the cellulose in these leaves during decomposition.

(4)

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(iv) The student repeated this investigation on sycamore leaves.

Explain why it would be necessary to keep the temperature of this investigation the same as the original.

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(Total for question = 11 marks)

Q24.

The scientific article you have studied is adapted from *National Geographic*.

Use the information from the scientific article and your own knowledge to answer the following questions.

Deduce how PERVs present in pig tissues could infect human cells (paragraph 25).

(2)

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(Total for question = 2 marks)

Q25.

Body farms use the bodies of pigs to study the changes in insect species on a body after death.

(i) Describe how this study could be carried out.

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(ii) Explain how the results of this study could be used to help to establish the time of death of a human.

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(Total for question = 6 marks)

Mark Scheme

Q1.

Question number	Answer	Additional guidance	Mark
	An answer that makes reference to two of the following: - the integrin binds to receptors - on (the surface of capillary) endothelial cells (1) - holding the immune cell in place / stopping the immune cell moving with the blood (1) - giving the immune cells time to squeeze between the endothelial cells (into the brain) (1)	ALLOW (complementary) proteins in place of receptors IGNORE activates (capillary) endothelial cells ALLOW trapping the immune cell ALLOW allowing immune cells to cross (the basement membrane / capillary wall)	(2)

Q2.

Question number	Answer	Additional guidance	Mark
(i)	An explanation that makes reference to two of the following: - primers have a specific base sequence (1) - bind to complementary bases (at either end) of the DNA to be amplified (1) - therefore, provide a site for the DNA polymerase to bind (1)	IGNORE contain complementary bases ALLOW primers attach to the start of the STR sequence ALLOW anneal for bind ALLOW allowing DNA polymerase to create a complementary strand	(2)

Question number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to three of the following: - the base sequences of the alleles are different (1) - the restriction enzyme {recognises / cuts} at a specific {site / DNA base sequence} (1) - that is only present in the G20210A allele (1) - therefore, a shorter fragment is produced for the G20210A allele (1)	ALLOW they have different numbers of base pairs e.g. wild type 345bp and the G20210A has 322bp	(3)

Question number	Answer	Additional guidance	Mark
(iii)	An answer that makes reference to four of the following: - identify an appropriate reagent to be provided (in excess) (1) - identify appropriate conditions (to control) (1) - change the number of cycles (1) - use gel electrophoresis (to determine quantity of DNA produced) (1) - choose the smallest number of cycles that produces an observable band (1)	e.g. DNA, polymerase, primers, mononucleotides e.g. temperatures used are 95, 55 and 70°C / duration of steps in cycle ALLOW a description of gel electrophoresis ALLOW choose the number of cycles giving the {thickest / clearest} band	(4)

Q3.

Question Number	Answer
	Answers will be credited according to candidates' deployment of knowledge and understanding of 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. Comparisons between phospholipid bilayer and proteins in the cell surface membrane: - judgement about the relative importance of the phospholipid bilayer and the proteins within that bilayer Use of data: - most proteins in the cell are associated with the cell membrane - whilst quantities of phospholipid are the same the proteins have more functions Importance of proteins in the cell surface membrane: - immune response e.g. as antigens and therefore body defence, antibodies, MHC proteins - receptors e.g. receptor proteins on tip of sperm allowing acrosome reaction when encounters zona, for neurotransmitters - regulation e.g. with regards to hormones such insulin - signal / transcription e.g. transcription factors, secondary messengers - transport e.g. active transport, as channel proteins allowing facilitated diffusion, as {voltage-gated / eq} channels for the nerve impulse / resting potential or / and role of Na⁺-K⁺ pump Importance of phospholipid bilayer in some of: - the role of fluidity and structure of cell the membrane - inhibiting polar substances moving across due to having a hydrophobic component - having both hydrophilic and hydrophobic components which leads to the separation of the aqueous contents of the cell from its aqueous external surroundings - allowing diffusion of gases directly across it - myelin sheath / nerve impulse

Level	Marks	Descriptor	Additional guidance
0		No awardable content	
1	1-3	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.	Discussion of one type of membrane protein linked to its role May have lots of irrelevant information
2	4-6	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of more than one piece of scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.	Discussion of more than one membrane protein linking them to their function Also discussing the role of phospholipids
3	7-9	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of several pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	Good discussion of role of proteins and phospholipids – reaching a judgement Linking role of proteins and phospholipids Number of specific examples of membrane proteins Very little if any irrelevant information

Q4.

Question Number	Indicative content
*	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. Basic information • All the treatment combinations were effective at treating TB • All treatments had some { relapses / individuals with TB } 3 years after treatment • { Group 1 / Groups 1 and 2 / Rifampicin + Pyrazinamide / Rifampicin + Isoniazid } had the lowest number of patients with TB (3 years later) Evidence for linkages made • Percentage relapse varies depending on second part of treatment • Combinations involving Rifampicin most effective • The antibiotics tested act on different targets in bacteria • Gaps in information - not all combinations tested, other combinations might be more effective • Other time scales may have been more effective Evidence for sustained scientific reasoning • Could be other reasons for infections with TB 3 years later not due to the antibiotic treatment • No information about dormant TB (only percentage of active cases) • Bacterial RNA polymerase possibly the best target for antibiotics • Antibiotics targeting synthesis of cell wall fatty acids least effective in terms of relapses • Idea of combination of antibiotics with different mode of activity most effective

Level	Mark	Descriptor	
Level 0	Marks	No awardable content	
Level 1	1-2	An answer may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The answer will contain basic information with some attempt made to link knowledge and understanding to the given context.	Reference to effectiveness of different combinations of antibiotics.
Level 2	3-4	An answer will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The answer shows some linkages and lines of scientific reasoning with some structure.	Reasons for differences in effectiveness considered.
Level 3	5-6	An answer 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 answer shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	Information about action of antibiotics related to effectiveness. Evaluation of study design considered.

Q5.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following: Any two of • more (new) cases • the total number of cases is relatively constant • and the number of people dying from TB is decreasing And • so {more are being successfully treated / the programme is effective}	ALLOW only slight change in total number of cases	(3)

Q6.

Question Number	Answer	Additional Guidance	Mark
(i)	- idea that bacteria are resistant to fewer {antibiotics / antibiotic combinations} (in 2006 than 2007) ; - in both years there are resistant strains to {streptomycin / INH + rifampicin + ethambutol / INH } ; - idea that there are resistant strains to INH + rifampicin in 2006 but not in 2007 ; - idea that there are resistant strains to {ethambutol / rifampicin} in 2007 but not in 2006 ;	ACCEPT clear abbreviations to the names of the antibiotics throughout 1 ACCEPT a description e.g. new resistances, resistant to 4 in 2006 and 5 in 2007 3 ACCEPT idea that {resistance decreased to zero / no longer resistant} 4 ACCEPT idea of resistance developing NB development of new resistances to {ethambutol / rifampicin} = Mp 1 and 4	(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	1. bacteria have a mutation in {DNA / gene / eq } ; 2. idea that the {presence / usage of} {antibiotic (INH) / INH} acts as a selection pressure ; 3. idea that the allele (for resistance) is passed on ; 4. idea that bacteria {divide by asexual reproduction / divide by binary fission / produce clones / eq} ; 5. idea of increasing the allele frequency ;	3 NOT gene 4 ACCEPT divide by mitosis / conjugation / transduction / transformation / eq	

Question Number	Answer	Additional Guidance	Mark
	6. idea that the more resistant bacteria there are, the more likely new strains will acquire the (resistance) gene ;		(3)

Question Number	Answer	Additional Guidance	Mark
(iii)	1. reference to codes of {practice / conduct / eq } ; 2. idea that appropriate {antibiotics / named example} should be given to patients ; 3. idea of {educating patients about taking antibiotics / taking the full course of antibiotics ; 4. credit another appropriate procedure e.g. hand washing, screening ;	1 ACCEPT named policy /code NB Mp5 is for named practice 2 ACCEPT not giving antibiotics if not necessary / not using antibiotics for prophylactic treatment / using narrow spectrum antibiotics / rotate antibiotic use	(2)

Q7.

Question Number	Answer	Additional guidance	Mark
(a)(i)	1. reference to {death / killing / destroying / eq } (of bacteria cells) ; 2. idea that {bacteria / cells} burst ;	1. Ignore reference to stopping growth 2. Accept lysis, loss of osmotic control	(2)

Question Number	Answer	Additional guidance	Mark
(a)(ii)	1. reference to cells cannot {reproduce / increase in number / produce new cells / multiply / replicate / eq} ; 2. idea of no (cell) division ;	2. Accept no binary fission	(2)

Question Number	Answer	Additional guidance	Mark
(b)(i)	1. (A and C resistant as) no {clear zone / zone of inhibition / eq} around A and C ; 2. idea that {clear zone / eq} indicates where antibiotic {inhibits growth / kills bacteria / eq} ; 3. {clear zone / eq} around B {smaller/ eq} than clear zone around D ; 4. idea of {size / diameter / width /eq} of clear zone indicates {effectiveness / eq} ; [check diagram for appropriate labels]	1. Accept a clear description of this area around the disc 2. Accept converse 3. Accept converse	(3)

Question Number	Answer	Mark
(b)(ii)	C reliability ;	(1)

Question Number	Answer	Mark
(b)(iii)	D validity;	(1)

Question Number	Answer	Additional guidance	Mark
(c)	- reference to hospitals {having / changing / eq } a {code of practice / protocol / policy / standards / eq} (for dealing with hospital acquired infections) ; - idea of clothing rules for hospital workers ; - reference to <u>improved</u> laundry of bed linen e.g. {<u>increased</u> frequency / higher washing temperature / eq} ; - reference to use of special {pillow cases / treatment of pillow cases} e.g. microfilters, treated with antibacterials, sterilisation, disposable pillow cases ; - reference to use of special procedures when carrying {pillow cases / bed linen} to laundry e.g. sealed plastic bags ; - screening of patients / isolation of infected patients / eq ; - idea of hand washing regimes / eq ;	1. Allow references to pillows for pillow cases throughout 3. Allow pillow cases should be washed daily 7. Allow hands should always be washed	(3)

Q8.

Question Number	Answer	Mark
(a)	A active artificial	(1)

Question Number	Answer	Additional Guidance	Mark
(b)(i)	1. antibodies appear (in blood) {immediately / on day 0 / eq} in group B but {on day 4 / after 3 days} in group A ; 2. antibodies reach higher levels in group B / eq ; 3. credit comparative manipulated data ;		(2)

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	1. antibodies present from the first vaccination / eq ; 2. idea of a secondary immune response ; 3. memory cells already present / eq ; 4. due to first vaccination / eq ; 5. memory cells mean that {antibodies produced immediately} / eq ; 6. on exposure to (same) antigen / eq ;		(3)

Question Number	Answer	Additional Guidance	Mark
(c)	1. idea that the virus will be destroyed quicker ; 2. {more / wider range of} memory cells present ; 3. so {higher levels / faster production} of antibodies ;		(2)

Question Number	Answer	Additional Guidance	Mark
(d)	Comparisons of groups A and B 1. not very reliable as sample size is small / eq ; 2. data for first 15 days after vaccination are reliable as error bars do not overlap ; 3. data for 30 and 60 days not reliable as error bars overlap ; Comparisons within either of the groups 4. there may be no change in the first fifteen days ;		(3)

Q9.

Question Number	Acceptable Answer	Additional guidance	Mark
(a)	A		(1)

Question Number	Indicative content		
*(b)	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. • Vaccination stimulates primary immune response • Reference to antigen presenting cells • Activation of T helper cells / reference to cytokines • Reference to B effector cells / activation of T killer cells • (Differentiation into) plasma cells that secrete antibody • Reference to memory cells • (Secondary immune response) antibody production is {sooner / faster / greater} for pathogen A • Insufficient antibody initially produced in primary response for pathogen B		
Level	Mark	Descriptor	
	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.
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.
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.

Q10.

Question number	Answer	Additional guidance	Mark
	A description that makes reference to the following: • { phagocytes / macrophages } engulf antigens (1) • antigen is presented on the surface of antigen presenting cells (1) • lymphocytes with receptors that are (specific / complementary) to (particular) antigens bind to APC (1)	ALLOW reference to production of APCs / antigen presenting cells ALLOW CD4 receptors ALLOW T cells for lymphocytes	(3)

Q11.

Question Number	Answer	Additional guidance	Mark												
	<table border="1"> <tr> <td></td><td>Keratin in the skin</td><td>Lysozyme in mucus</td><td>Hydrochloric acid in the stomach</td></tr> <tr> <td>Physical barrier</td><td>✓</td><td>x</td><td>x</td></tr> <tr> <td>Chemical barrier</td><td>x</td><td>✓</td><td>✓</td></tr> </table>		Keratin in the skin	Lysozyme in mucus	Hydrochloric acid in the stomach	Physical barrier	✓	x	x	Chemical barrier	x	✓	✓	3 correct answers 1 mark All correct 2 marks	(2)
	Keratin in the skin	Lysozyme in mucus	Hydrochloric acid in the stomach												
Physical barrier	✓	x	x												
Chemical barrier	x	✓	✓												

Q12.

Question Number	Answer	Additional Guidance	Mark
(a)	1. bacteria have DNA, viruses have DNA or RNA ; 2. idea that bacteria have {circular / eq} genetic material, viruses have {linear / straight} ; 3. bacterial DNA is double-stranded, viral {DNA / RNA} is single (or double) stranded / eq; 4. bacteria (may) have plasmids, viruses do not have plasmids / eq;	NB piece answers together throughout Do not accept in context of plasmid	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(i)	1. reference to {phagocytosis /endocytosis / engulfing} ; 2. credit details of phagocytosis ; 3. reference to bacterium inside a {vacuole / vesicle / phagolysosome} ;	eg formation of {pseudopodia / membrane extensions around bacteria} / cytoplasmic streaming / binding to bacteria Not phagolysosome	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	- idea that bacteria need to be accessible to antibiotics ; - idea of bacteria inside macrophages ; - reference to waxy layer of (these) bacteria ; - idea that (bacteriostatic) antibiotics affect dividing bacteria; - reference to antibiotic resistance (of these bacteria) ;	Not bacteriocidal antibiotics	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	- idea of {dead / attenuated / eq} {organisms / pathogen / bacterium / eq} put into person; - reference to (stimulation of) {specific / primary} (immune) response ; - credit details of T helper cell activation ; - credit details of B cell activation ; - credit details of T killer cell activation ; - reference to production of memory cells ;	NB not simply crediting ref to vaccination as in stem of question Accept antigen eg macrophages as APCs eg involvement of cytokines, B cells as APCs eg involvement of cytokines, infected cells as APCs	(3)

Question Number	Answer	Additional Guidance	Mark
(c)	- reference to {further lung damage / severe breathing problems / eq} ; - idea that the <i>Mycobacterium</i> get into the {blood / lymph}; - idea that organ failure (leads to death) ; - idea of {reduced / weakened} immune response (due to a loss of T cells) ; - credit detail of role of T (helper) cells ; - credit detail of effect of no T killer cells ; - credit detail of effect of no B cells ; - ref to {secondary / opportunistic / other} infections (causing death) ;	eg cannot obtain enough oxygen eg production of cytokines eg infected cells will not be destroyed eg no antibody produced	(4)

Q13.

Question Number	Answer	Additional guidance	Mark
(i)	A description that makes reference to three of the following • (small groups of) healthy volunteers are given the vaccine to test for side effects (1) • (healthy volunteers) tested for presence of antibodies to the virus (following vaccination) (1) • a group of people at risk of contracting the disease is given the vaccine (1) • the number of people who develop the viral disease (following vaccination) are monitored (1)		(3)

Question Number	Answer	Additional guidance	Mark
(ii)	An answer that makes reference to four of the following • large numbers of people died from the disease (1) • health workers are in close contact with people suffering from the disease (1) • the side effects of the vaccine will not be worse than contracting Ebola (1) • vaccinating immediate family will help to reduce the spread of disease (1) • if health workers were vaccinated they could care for more people (1)	ALLOW disease is (usually) fatal ALLOW health workers and family most likely to be exposed to the virus ALLOW risk from the disease is much greater than the risk from the vaccine	(4)

Q14.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to three of the following: <u>Similarities</u> • both contain { genetic material / RNA } (1) • both have a phospholipid bilayer (1) <u>Differences</u> • (only) bacteria have { cytoplasm / ribosomes / pili / slime capsule / flagellum / cell wall / cell membrane / plasmid } (1) • (only) HIV has { capsid / protein coat / GP 120 } (1)	IGNORE both have DNA ALLOW lipid bilayer ALLOW converse i.e. HIV does not have... ALLOW converse i.e. bacterium does not have...	(3)

Q15.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to four of the following: <u>Similarities</u> • to avoid adverse environmental conditions (1) • formation of resistant {outer coating / capsule} (1) • reduce metabolic activity (1) <u>Differences</u> • sporulation and no sporulation (1) • different reasons for entering dormancy (1) • (only) genetic material is in a protective capsule in Bacillus (1)	e.g. mycobacterium enters dormancy to avoid immune response and Bacillus to survive lack of resources	(4)

Q16.

Question Number	Answer	Mark
	B - smaller than ribosomes in eukaryotes <i>The only correct answer is B</i> <i>A is not correct because bacterial ribosomes are smaller than eukaryotic ribosomes</i> <i>C is not correct because bacterial ribosomes are smaller than animal ribosomes</i> <i>D is not correct because bacterial ribosomes are smaller than plant ribosomes</i>	(1)

Q17.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to two of the following: - only one cell as opposed to potentially many (1) - no nucleus present (1) - no membrane-bound organelles present / absence of named membrane-bound organelle other than nucleus (1)	ALLOW DNA not associated with histones ALLOW example e.g. no mitochondrion	(2)

Q18.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following: - at the start of composting the percentage of organic carbon is less and the percentage of nitrogen is more when cow dung is added (1) - adding cow dung does not change the decrease in organic carbon (1) - adding cow dung causes {a slight / no change} to the increase in nitrogen (1) - adding cow dung has no significant effect on composting (of coffee husks) (1)	e.g. 12.8% and 12.7% e.g. 0.43% compared with 0.47%	3

Q19.

Question Number	Indicative content	
*	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. - the CVID group is more susceptible to bacterial infections - the CVID group produces fewer antibodies to bacterial antigens - have a reduced percentage of B cells - have a similar ratio of T helper to T killer cells - have a normal percentage of T lymphocytes - can defend themselves against viruses but not bacteria (therefore) antiviral medication not required - could prescribe (prophylactic) antibiotics - could provide passive immunity by giving them antibodies / immunoglobulins	
Level	Mark	Descriptor
0	0	No awardable content
1	1-2	Limited scientific judgement made with a focus

Level	Mark	Descriptor
		on mainly just one method, with a few strengths/weaknesses identified. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.
2	3-4	A scientific judgement is made through the application of relevant evidence, with strengths and weaknesses of each method identified. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.
3	5-6	A scientific judgement is made which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.

Q20.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	positive correlation		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	- correct diameter or radius measured (1) - correct answer (1)	14 mm <u>Example of Calculation</u> $3.14 \times 7^2 = 154 \text{ mm}^2$ Allow full marks for correct answer with no working	(2)

Q21.

Question Number	Answer	Mark
(a)	C hydrolysis	(1)

Question Number	Answer	Mark
(b)(i)	B to give a range of values for the independent variable	(1)

Question Number	Answer	Mark
(b)(ii)	B one	(1)

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	- idea that {bacteria / fungi / decomposers / eq} release enzymes (for decomposition) ; - idea of the formation of {monomers / glucose / amino acids / small molecules} / eq ; - that {are soluble / dissolve} ; - idea that some (soluble) molecules {soak into the ground / taken up (by organisms)} ; - idea of {respiration / fermentation} of {glucose / eq} (by decomposers); - carbon dioxide (released) / eq ; - idea of water loss ; - idea of {worm / appropriate named organism} activity;	- ACCEPT external digestion / extracellular digestion - e.g. evaporation of water / leaves drying out - e.g. animals eat the leaves, leaves pulled into soil	(4)

Question Number	Answer	Additional Guidance	Mark
(b)(iv)	- idea that an increase in temperature would increase the rate of decomposition (up to an optimum temperature) ; - reference to enzymes (in decomposition) ; - idea that increased {heat / kinetic} energy results increase in {number of collisions / energy of collisions (between enzymes and substrate) / enzyme-substrate complexes} ; - idea that increased temperature increases rate at which bacteria increase ; - idea that above a certain temperature rate of decomposition would {decrease / stop} ; - idea that at higher temperatures enzymes become denatured OR bacteria killed ;	6. NOT enzymes start to denature NB need the term 'denaturing' or its derivative	(4)

Q22.

Question Number	Acceptable Answer	Additional guidance	Mark
(a)	larvae show no significant preference for light over dark side (1)	Allow vice versa Must have NO in hypothesis.	(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(i)	calculation of expected frequency 10 and 10 (1) (O-E) ² / E for both light and dark sides $49 \div 10 = 4.9$ (1) sum = 9.8 (1)		(3)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(ii)	An answer that makes reference to the following: higher than 3.84 therefore Chi square value as high as 9.8 arise by chance alone less than 1 in 20 / 0.05 therefore there is a significant difference (1)	allow ECF for incorrect value of Chi allow converse if calculated of Chi is lower than 3.84	(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(c)	An explanation that makes reference to five of the following: - use of dead tissue containing toxin and dead tissue not containing tissue so valid comparison can be made (1) {young larvae of same length / fly eggs} allowed access to both types of dead tissue so they have same potential for growth (1) - reference to time scale before growth of larvae measured to allow time for growth to occur (1) - length measured for several larvae to ensure reliability (1) - control of {temperature / type of tissue / age of tissue / species of larvae} because these factors affect growth (1) - recognition that comparison of results may show under or over estimate of time of death (1)		(5)

Q23.

Question Number	Answer	Mark
(a)	A bacteria and fungi	(1)

Question Number	Answer	Mark
(b)(i)	A none	(1)

Question Number	Answer	Mark
(b)(ii)	D validity	(1)

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	1. 2. ref to hydrolysis ; 3. by {enzymes / cellulase} / eq ; 4. produced by microorganisms / eq ; 5. into(β) glucose ; 6. uptake of glucose into microorganisms / eq ; 7. idea that glucose is used in {respiration / fermentation} ; 8. releasing carbon dioxide into the atmosphere / eq ; 9. idea that some of glucose (solution) soaks into ground ;		(4)

Question Number	Answer	Additional Guidance	Mark
(b)(iv)	1. to make investigation valid ; 2. idea that {temperature / heat energy} affects {rate of enzyme reactions / enzyme activity / rate of decomposition} ; 3. increase in {heat / kinetic} energy results in more {collisions / energetic collision / enzyme-substrate complexes / eq} ; 4. idea that high temperature results in enzyme {denaturing / becoming denatured} ; 5. (so) decomposition would stop / eq ;	4. ACCEPT bacteria killed / eq	(4)

Q24.

Question number	Answer	Additional guidance	Mark
	An answer that makes reference to two of the following: • PERVs (are retroviruses) present in the pig's genome (1) • PERV virus particles {are produced by / bud of from} the pig cells (1) • PERVs bind to membrane receptors (on human cells) (1) • PERVs insert their nucleic acid into the cells (1)	ALLOW pigs inherit the PERVs / retroviruses in their genomic DNA ALLOW membrane coated particles fuse with human cells ALLOW enter cells by endocytosis	Choose an item. (2)

Q25.

Question Number	Answer	Additional guidance	Mark
(i)	A description that makes reference to three of the following: • standardisation of pigs studied (1) • named {environmental condition / abiotic factor} controlled (1) • record the presence of different species (of insects) (1) • at regular intervals of time (1)	e.g. same {size / breed / mass / type / age /sex} ALLOW example of an abiotic factor being monitored such as temperature e.g. every 24 hours, every day, hourly, weekly	(3)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to three of the following: • record which {insects / species} are present (on the human) (1) • compare with results from investigation (on pigs) to determine time of death (1) • take into account which stages of the lifecycle are present (1) • (when using stage of succession to determine time of death) environmental variables need to be taken into account (1)		(3)

Q1.

The extent of decomposition is important in helping to determine the time of death of a mammal.

Body farms are outdoor laboratories where experiments take place to investigate the changes that take place after death in a range of conditions. Body farms use the bodies of pigs or donated human bodies.

The effects of factors such as temperature, moisture and position of the body on the rate of decomposition can be studied.

Explain the effect of ambient temperature on the rate of decomposition.

(3)

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(Total for question = 3 marks)

Q2.

The time of death of a person can be estimated in a number of ways. One method is to use a Henssge nomogram.

The Henssge nomogram relates the time of death to the ambient (surrounding) temperature, the core temperature and the mass of the body.

Explain why the ambient temperature and the core temperature of the body are used to determine the time of death of a person.

(3)

Q3.

A dead human body can supply a variety of evidence to support the time of death.

The table shows the relationship between the mean rectal temperature, calculated from a number of human bodies, and time after death. All bodies were at the same ambient temperature.

Time after death / hours	Mean rectal temperature / °C	Range of rectal temperature / °C
4	36	±1.8
8	31	±2.5
12	28	±3.3
16	26	±4.3
20	24	±5.1
24	22	±5.6

(a) Deduce the maximum ambient temperature.

(2)

(b) Analyse the data to explain why a more reliable estimate of time of death could be given if the dead body has a higher rectal temperature.

(2)

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(c) State **two** features of these bodies that could account for the variation in the data.

(2)

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(d) Explain why recording rectal temperature is more reliable than measuring skin temperature.

(2)

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(e) In addition to body temperature, forensic scientists would look for other evidence of time of death.

Give **two** other pieces of evidence from a body that allow for an estimation of the time of death.

(2)

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(Total for question = 10 marks)

Q4.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Farmers use fertilisers to increase the growth of crops such as wheat.

(i) Fertilisers contain phosphate ion compounds.

Plants need phosphate in order to synthesise

(1)

- ☐ **A** both cellulose and phospholipids
- ☐ **B** both phospholipids and polysaccharides
- ☐ **C** both polynucleotides and phospholipids
- ☐ **D** both polynucleotides and polysaccharides

(ii) After the grain is harvested, farmers plough the stems (straw) from wheat plants into the soil.

This improves the quality of the soil. These stems contain polysaccharides.

Explain how microorganisms in the soil break down the stems.

(3)

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(Total for question = 4 marks)

Q5.

Researchers carried out a study on the prey of predatory ground beetles. They removed the contents of the guts of beetles which had been feeding and analysed them to see if they could identify the species they had fed on.

In one study, to see if the method worked, they fed the beetles on earthworms of the species *Allolobophora chlorotica* only.

DNA was extracted from the gut contents and analysed.

(a) The quantity of worm DNA in the beetle gut was very small.

Describe how sufficient DNA was produced to carry out the analysis.

(3)

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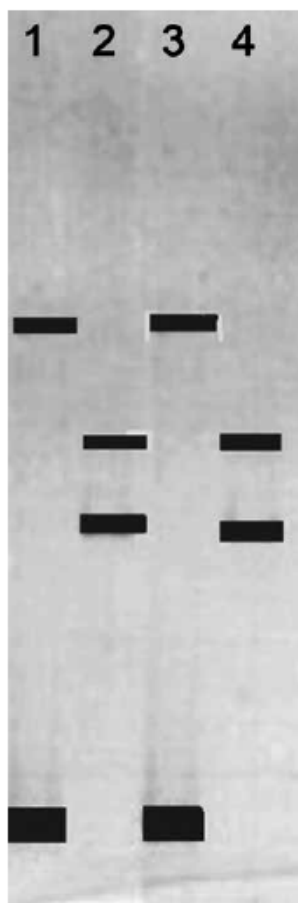
(b) (i) The DNA in the samples from the beetle guts was cut into fragments. The fragments were different for each species and had to be separated by gel electrophoresis.

Which of the following describes the movement of the DNA fragments in gel electrophoresis?

(1)

- ☐ **A** large fragments move further than small fragments towards the anode
- ☐ **B** large fragments move further than small fragments towards the cathode
- ☐ **C** small fragments move further than large fragments towards the anode
- ☐ **D** small fragments move further than large fragments towards the cathode

(ii) The picture shows one set of results in which four samples have been separated.



(Source: Evaluation of temperature gradient gel electrophoresis for the analysis of prey DNA within the guts of invertebrate Sheppard et al. Cardiff School of Biosciences)

Explain what these results show you about the diet of the ground beetles.

(2)

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(Total for question = 6 marks)

Q6.

Acetylcholinesterase is an enzyme involved in regulating the transmission of nerve impulses across some synapses.

Acetylcholinesterase is found on the cell surface membranes of neurones and red blood cells.

These acetylcholinesterase molecules have different primary structures.

In humans, a single gene codes for acetylcholinesterase.

(i) Explain how a single gene can give rise to acetylcholinesterase molecules with different primary structures.

(2)

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(ii) Explain how the acetylcholinesterase gene can be expressed in some tissues but not others.

(3)

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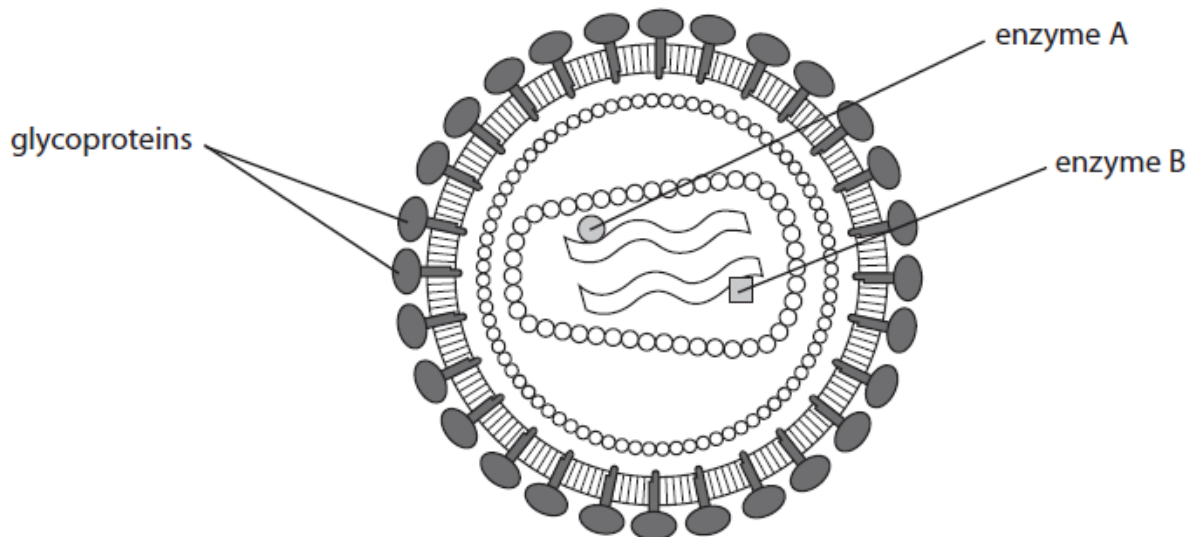
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(Total for question = 5 marks)

Q7.

Anti-viral drugs have been developed to treat patients infected with Human Immunodeficiency Virus (HIV).

The diagram below shows the structure of HIV.



(a) A glycoprotein has a carbohydrate attached to a protein molecule. Describe the three-dimensional structure of a glycoprotein.

(3)

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(b) Some anti-viral drugs prevent HIV entering the host cells.

Suggest how these anti-viral drugs could prevent HIV entering the host cells.

(3)

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*(c) Describe how the enzymes shown in the diagram are involved in HIV infection.

(5)

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(Total for question = 11 marks)

Q8.

The Human Immunodeficiency Virus (HIV) infects cells of the human immune system.

(a) (i) Place a cross (☒) in the box next to the name of the type of cell in the human immune system that is infected by HIV.

(1)

- ☐ **A** B effector cell
- ☐ **B** B memory cell
- ☐ **C** T helper cell
- ☐ **D** T killer cell

(ii) Place a cross (☒) in the box next to the name of the enzyme used to produce DNA from viral RNA in an infected cell.

(1)

- ☐ **A** DNA polymerase
- ☐ **B** RNA polymerase
- ☐ **C** restriction endonuclease
- ☐ **D** reverse transcriptase

(b) An antibody, known as 2G12, has been isolated from the blood of an HIV patient.

(i) State **two** characteristic features of antibodies.

(2)

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*(ii) The antibody 2G12 is produced in response to part of a glycoprotein found on the surface of HIV. Synthetic molecules have been made that resemble this part of the glycoprotein. The antibody 2G12 binds to these synthetic molecules.

Using the information, suggest how this may enable scientists to develop a means of producing **active** immunity to HIV infection.

(5)

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(c) The table below shows some data about groups of people with HIV infection, in the United Kingdom in 2010.

Group	Numbers in the United Kingdom
People newly-diagnosed with HIV infection	6 630
People unaware of their HIV infection	21 625
People receiving treatment for HIV infection	65 000

Some of the figures shown in the table are estimates.

Suggest why data about HIV infections are often estimates.

(2)

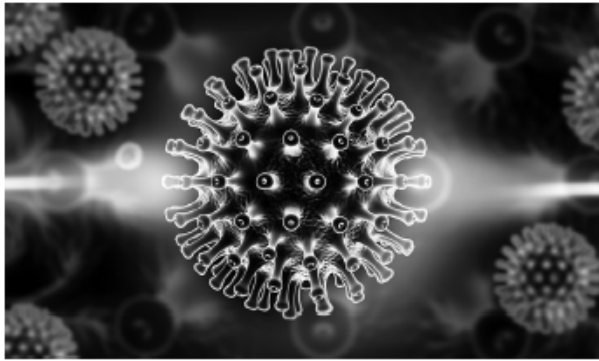
(Total for question = 11 marks)

Q9.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer

with a cross ☒.

The human immunodeficiency virus (HIV), shown in the image, causes acquired immunodeficiency syndrome (AIDS).



© Liya Graphics/Shutterstock

HIV particles contain

(1)

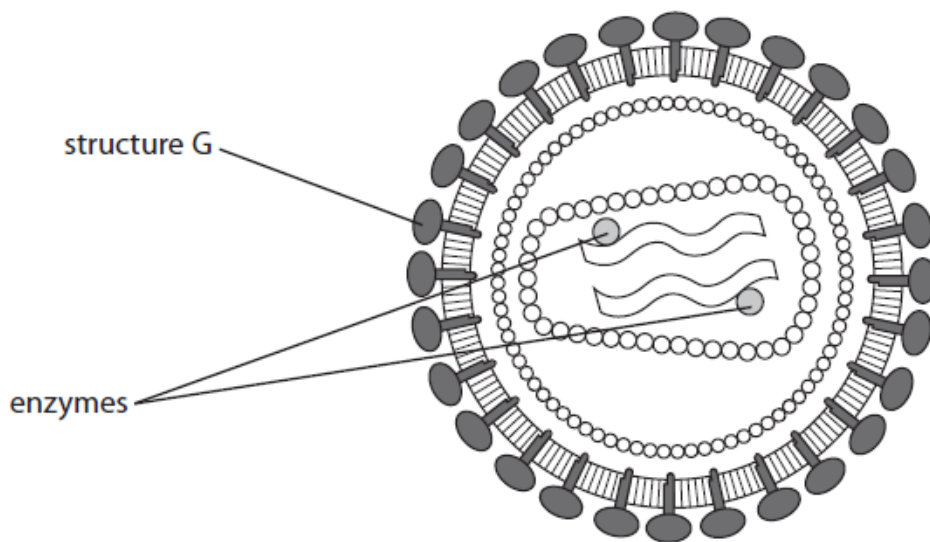
- ☐ **A** DNA and DNA polymerase
- ☐ **B** DNA and reverse transcriptase
- ☐ **C** RNA and DNA polymerase
- ☐ **D** RNA and reverse transcriptase

(Total for question = 1 mark)

Q10.

Anti-viral drugs have been developed to treat patients infected with Human Immunodeficiency Virus (HIV).

The diagram below shows the structure of HIV.



(a) Explain how **structure G** enables HIV to infect human cells.

(3)

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(b) Some anti-viral drugs used to treat patients infected with HIV are inhibitors of enzymes found within HIV.

(i) Describe the structure of an enzyme.

(3)

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*(ii) Suggest how these anti-viral drugs would work in the treatment of patients infected with HIV.

(5)

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(Total for question = 11 marks)

Q11.

The scientific article you have studied is adapted from *Scientific American*.

Use the information from the scientific article and your own knowledge to answer the following question.

Describe how a cell that is 'a key player in the body's immune system' differs from a stem cell (paragraph 14).

(4)

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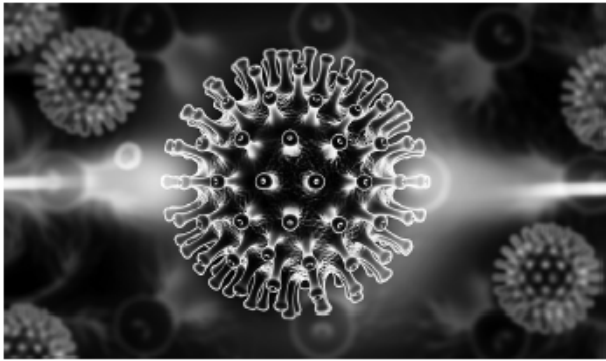
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(Total for question = 4 marks)

Q12.

The human immunodeficiency virus (HIV), shown in the image, causes acquired immunodeficiency syndrome (AIDS).



© Liya Graphics/Shutterstock

HIV enters and destroys T helper cells. This can cause AIDS.

(i) Describe how HIV particles are able to enter T helper cells.

(3)

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(ii) Explain why the destruction of T helper cells causes the symptoms of AIDS.

(4)

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(Total for question = 7 marks)

Q13.

Answer the question with a cross in the box you think is correct ☐. If you change your

mind about an answer, put a line through the box ☐ and then mark your new answer with a cross ☒.

A bacteriostatic antibiotic works by

(1)

- ☐ **A** destroying bacteria
- ☐ **B** destroying viruses
- ☐ **C** preventing the multiplication of bacteria
- ☐ **D** preventing the development of antibiotic resistance

(Total for question = 1 mark)

Q14.

A newborn baby can respond to infections.

The mother of a baby will produce an immune response to any infections that she acquires.

Antibodies providing specific immunity to these infections are found in the milk produced by the mother.

(i) Which cell produces antibodies?

(1)

- ☐ **A** macrophage
- ☐ **B** plasma cell
- ☐ **C** red blood cell
- ☐ **D** T cell

(ii) The type of immunity that the newborn baby obtains from the milk produced by its mother is

(1)

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

- ☒ **D** natural passive immunity

(Total for question = 2 marks)

Q15. Bacteria and viruses can cause human diseases.

(a) Distinguish between the structure of bacteria and viruses

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(b) Infection with a bacterium can result in the development of active immunity to that bacterium. This results in the production of antibodies by plasma cells.

(i) Describe how infection with a bacterium results in the production of plasma cells.

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(ii) Explain how antibodies help a person to recover from an infection.

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(iii) A person who has had an organ transplant has to take immunosuppressive drugs. This prevents the immune system from destroying the organ transplant. Some of these drugs work by inhibiting the production of cytokines.

Suggest what effect these drugs could have on a person infected with a bacterium or a virus.

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(Total for Question = 13 marks)

Q16.

The scientific article you have studied is from *Scientific American*.

Use the information from the scientific article and your own knowledge to answer the following question.

'Innate immunity initiates the inflammatory response, in which white blood cells swarm the site of infection' (paragraph 5).

Explain how white blood cells 'swarm' to accumulate at the site of inflammation.

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(Total for question = 4 marks)

Q17.

The scientific article you have studied is adapted from *Scientific American*.

Use the information from the scientific article and your own knowledge to answer the following question.

Explain how inflammation and the immune response can cause damage to tissues (paragraph 4).

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(Total for question = 3 marks)

Q18.

The coffee husks, shown in the photograph, are a waste product of coffee plantations.

Composting has been suggested as an environmentally friendly way of decomposing these coffee husks.



The effect of adding cow dung to coffee husks, before they are composted, has been investigated.

The table shows the percentages of organic carbon and nitrogen in two compost heaps at the start of composting and after 90 days.

	Husks alone		Husks with added cow dung	
Days composting	0	90	0	90
Organic carbon (%)	54.50	41.70	48.10	35.40
Nitrogen (%)	1.84	2.31	2.76	3.19

* The changes in the compost heaps are due to the activity of decomposers and other organisms.

Devise an investigation to determine the effect of the carbon to nitrogen ratio on the succession of species in these compost heaps.

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(Total for question = 6 marks)

Q19.

Measles is a contagious disease that can be controlled by vaccination.

Not all parents choose to have their children vaccinated.

The table shows the number of cases of measles and the percentage of children vaccinated in the UK between 2012 and 2017.

Year	Number of cases of measles	Percentage of children vaccinated (%)
2012	1564	91.2
2013	1855	92.3
2014	135	92.7
2015	71	92.3
2016	556	91.9
2017	216	91.6

(i) Calculate the percentage change in the number of cases of measles from 2013 to 2014.

Give your answer to three significant figures.

(2)

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(ii) One conclusion from the data is that it takes time for an increase in vaccination rate to reduce the number of cases of measles in children.

Explain why this is a valid conclusion.

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Q20.

Measles is a contagious disease that can be controlled by vaccination.

The incidence of measles has risen by 300% worldwide in recent years.

A study has found that some B memory cells and antibodies are destroyed by the measles virus.

(i) Antibodies are released into the blood when

(1)

- ☐ **A** B cells are activated to become killer cells
- ☐ **B** B cells are activated to become plasma cells
- ☐ **C** macrophages are activated to become B cells
- ☐ **D** plasma cells are activated to become memory cells.

(ii) Vaccinations are carried out against many serious diseases.

Vaccination leads to the production of antibodies and memory cells.

Which kind of immunity is provided by this type of vaccination?

(1)

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

(iii) Explain why, following a measles infection, it may be advisable for children to repeat other vaccinations they have had.

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(Total for question = 5 marks)

Q21.

Humans are surrounded by microorganisms in the air, water and food.
Some microorganisms are pathogenic.
The human body has several barriers to prevent infection by pathogens.

Explain why the presence of microorganisms on the skin and in the gut helps to prevent pathogenic organisms multiplying in the body.

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(Total for question = 3 marks)

Q22.

Thalassaemia is a recessive genetic disorder that affects the production of haemoglobin. It is caused by a gene mutation.

Scientists are developing methods to repair gene mutations such as the one that causes thalassaemia.

The RNA produced during transcription is known as pre-mRNA. Pre-mRNA can be modified before being translated on the ribosome.

(i) Describe how the pre-mRNA may be modified before being translated on the ribosome.

(2)

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(ii) Explain why modification of pre-mRNA enables one gene to give rise to more than one protein.

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(Total for question = 4 marks)

Q23.

The neurones of the central nervous system contain TAU proteins. These proteins help to maintain cell structure.

In humans, six different TAU proteins can be produced from a single gene.

Parkinson's disease has been linked to the different forms of the TAU proteins present in neurones.

Scientists are studying the effect of these different TAU proteins in animal models.

One model used is the fruit fly, *Drosophila*.

Describe how *Drosophila* flies could be genetically modified to produce one form of the human TAU protein.

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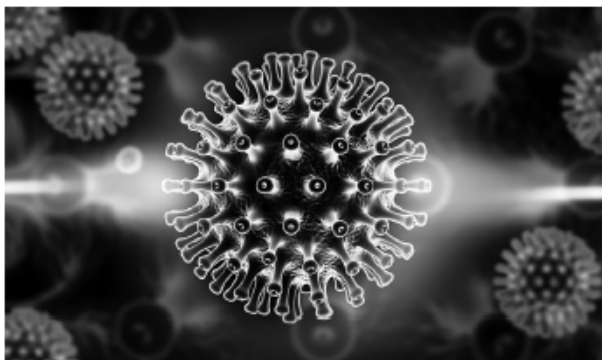
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(Total for question = 4 marks)

Q24.

The human immunodeficiency virus (HIV), shown in the image, causes acquired immunodeficiency syndrome (AIDS).



© Liya Graphics/Shutterstock

A small number of people have been identified who are resistant to HIV.

They have a mutation in a gene coding for a protein in the cell membrane.

(i) Deduce why this mutation makes these people resistant to HIV infection.

(2)

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(ii) Stem cell therapy can be used to treat patients infected with HIV.

The bone marrow of these patients can be destroyed using radiotherapy.

The patients can then be given stem cells from the bone marrow of a donor who has this mutation.

Explain why these stem cells may prevent HIV causing AIDS.

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(Total for question = 6 marks)

Q25.

The human body responds to infection by bacteria in a number of ways.

The non-specific response includes phagocytosis and lysozyme action, which can be followed by the specific immune response. The specific immune response requires antigen presentation by macrophages.

(a) Explain how phagocytosis and lysozyme action lead to antigen presentation by macrophages.

(4)

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(b) Explain how macrophages present antigens to T helper cells.

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(c) There is an 'evolutionary race' between some bacteria, such as *Mycobacterium tuberculosis* (TB), and their hosts.

Suggest how this could affect antigen presentation to T helper cells.
Give an explanation for your answer.

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(Total for question = 9 marks)

Mark Scheme

Q1.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following • an increase in temperature will increase the rate of { decomposition / decay } (1) • (an increase in temperature) increases enzyme activity (1) • an increase in temperature increases growth rate of {bacteria / fungi / decomposers} (1)	ALLOW converse for all points for the effects of a decrease in temperature ALLOW high temperatures may denature enzymes and decrease rate of decomposition ALLOW increases rate of multiplication	(3)

Q2.

Question Number	Answer	Additional Guidance	Mark
	1. idea that the temperature of the {body / core} changes (with time after death) ; 2. idea that (core) temperature depends upon the {ambient / eq} temperature ; 3. idea that {other post-death changes / muscle contraction / insect life cycles / decomposition / eq} depend on (ambient / body) temperature ;	1 ACCEPT cooling	(3)

Q3.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	- correct reading of temperatures (1) - after 24 hours, lowest body temperature 22 minus 5.6°C (1)	22 ±5.6 Accept calculation of maximum ambient temperature <u>Example of calculation</u> 22 – 5.6 = (lower than / equal to) 16.4°C	(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)	An answer that makes reference to the following: (1) - range smaller at higher temps (1) - only the highest temperature shows no overlap		(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)	An answer that makes reference to two of the following: - body size (1) - fat level (1) - position of body i.e. in fetal position or not (1)		(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(d)	An explanation that makes reference to the following: - rectal temperature is core temperature / it would be 37°C at time of death (1) - skin surface temperature would be more variable (1)		(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(e)	An answer that makes reference to two of the following: - rigor mortis (1) - degree of decomposition (1) - forensic entomology (1)		(2)

Q4.

Question Number	Answer	Mark
(i)	The only correct answer is C – polynucleotides and phospholipids <i>A is incorrect because phosphate is not in cellulose</i> <i>B is incorrect because polysaccharides do not contain phosphate</i> <i>D is incorrect because phosphate is not in polysaccharides</i>	(1)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to three of the following - the stems contain starch or cellulose(1) - enzymes are { secreted / released } by the microorganisms (1) - which break down the glycosidic bonds(1) - which releases glucose that is used by the microorganisms in respiration (1)	ALLOW lignin ALLOW enzymes from microorganisms digest(starch/ cellulose)	(3)

Q5.

Question Number	Acceptable Answer	Additional guidance	Mark
(a)	A description that makes reference to the following: - reference to PCR to include reference to {primers / DNA polymerase / nucleotides} (1) - procedure repeated {multiple times / 20 to 40 times} (1) - temperature requirements to denature and anneal (1)		(3)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(i)	C		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(ii)	An explanation that makes reference to: - pattern of bands different between 1 and 3 and 2 and 4 (1) - so <i>Allolobophora chlorotica</i> not all one species (1)		(2)

Q6.

Question number	Answer	Additional guidance	Mark
(i)	An explanation that makes reference to two of the following: • (pre-)mRNA splicing / post-transcriptional modification (1) • different exons removed (1) • (therefore) producing different {sequences of amino acids / mRNA sequences} (1)	ALLOW the exons can be joined in different sequences ALLOW (the acetylcholinesterase) gene is made up from several exons and introns IGNORE producing different primary structure	Choose an item. (2)

Question number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to three of the following: • {hormones / signal molecules / chemical signals} bind to receptors found only in some {tissues / cells} (1) • regulating a {transcription factor / repressor molecules} (1) • {transcription factor / repressor molecule} binds to the promoter region of the (acetylcholinesterase) gene (1) • therefore switching {on / off} transcription (1)	ALLOW epigenetic changes occur in some tissues ALLOW only act on some {tissues / cells} ALLOW {allowing / preventing} binding of RNA polymerase	Choose an item. (3)

Q7.

Question Number	Answer	Additional Guidance	Mark
(a)	1. proteins consist of amino acids joined together by peptide bonds; 2. credit reference to named bonds (between R groups) involved in holding {3D structure / eq} ; 3. carbohydrates consist of {monosaccharides / glucose / eq} ; 4. reference to glycosidic {bonds / eq} between (adjacent) {glucose / eq} molecules ;		(3)

Question Number	Answer	Additional Guidance	Mark
(b)	1. idea that the drugs could {bind to / alter shape of} {glycoproteins / gp120} ; 2. idea that drugs bind to {receptors / antigens} on membrane / eq ; 3. called CD4 (antigen / molecules) ; 4. preventing virus attaching to T (helper / CD4⁺) cells / eq ;		(3)

Question Number	Answer	Additional Guidance	Mark
*(c)	(QWC – spelling of technical terms must be correct and the answer must be organised in a logical sequence) 1. reference to reverse transcriptase ; 2. idea of formation of (viral) DNA ; 3. from (viral) RNA ; 4. reference to integrase ; 5. idea of integration of (viral) DNA into (host) DNA ; 6. idea that {T helper cells / eq} would be {destroyed / killed / burst / eq} (by virus particles leaving cell) ; 7. idea that more T (helper) cells would become infected ;	QWC focussing on clarity of expression 2. reject idea that RNA is {turned into / converted into} DNA 5. ACCEPT idea of {latency / formation of provirus / eq}	(5)

Q8.

Question Number	Answer	Mark
(a)(i)	C T helper cells ;	(1)

Question Number	Answer	Mark
(a)(ii)	D reverse transcriptase ;	(1)

Question Number	Answer	Additional guidance	Mark
(b)(i)	- reference to glycoprotein ; - credit detail of structure e.g. specific (3D) shape, L and H regions, Y-shape, 4 (peptide) chains, disulphide bridges between peptides, hinge region ; - reference to {antigen-binding site / variable region / Fab (region) / eq }; - idea of antibodies have a {similar / constant / Fc / eq } region; - produced by plasma cells / present on B cells ; - role of antibody described e.g. opsonisation, immobilisation, agglutination, lysis ;	1. Accept protein, chains of amino acids 2. Ignore active site Accept a Y-shaped drawing 3. Accept references to {binding to specific antigen / antigen-specific / antigen receptors} 5. Accept present on B effector cells	(2)

Question Number	Answer	Additional guidance	Mark
*(b)(ii)	(QWC – answer must be organised in a clear, logical sequence) 1. reference to artificial (active) immunity ; 2. reference to {vaccine / vaccination} ; 3. containing {synthetic molecule / (synthetic) antigen / (synthetic) glycoprotein} ; 4. ref to stimulation of the {specific / humoral} immune response (to the synthetic antigen) ; 5. credit detail of process of producing effector B cells e.g. clonal expansion of B cells, involvement of cytokines, T helper cells activate B cells ; 6. reference to (production of B) memory cells ; 7. idea that (2G12) antibodies are produced {faster / in greater concentration} on {reinfection / eq} ;	Mps are awarded if the statements are clearly expressed 5. Ignore references to production of activated T killer cells 6. Ignore references to production of T memory cells 7. Accept ref to secondary immune response	(5)

Question Number	Answer	Additional guidance	Mark
(c)	1. idea that HIV infection does not always produce symptoms ; 2. reference to {provirus / latency} ; 3. reference to test needed to detect (symptomless) HIV ; 4. idea that only people who suspect they may have contracted HIV would have a test ; 5. idea that {some people would not want to be tested / impossible to test everyone} ; 6. idea that symptoms are common to other diseases ; 7. {new cases arising/ patients dying} all the time / eq ; 8. idea of new strains of virus arising ;	2. Accept virus is dormant	(2)

Q9.

Question Number	Answer	Mark
	The only correct answer is D - RNA and reverse transcriptase <i>A is incorrect because it does not contain DNA</i> <i>B is incorrect because it does not contain DNA</i> <i>C is incorrect because it does not contain DNA polymerase</i>	(1)

Q10.

Question Number	Answer	Additional Guidance	Mark
(a)	(structure G is {glycoprotein / gp120} ; - used for {attachment / eq} to CD4 (molecules / receptors / antigens) ; - on T helper {cells / lymphocytes} ;	- IGNORE gp 41 and gp 160 and other wrong numbers - ACCEPT macrophages / dendritic cells / CD4 cells	(3)

Question Number	Answer	Additional Guidance	Mark
(b)(i)	- they are globular proteins ; - it has an active site ; - idea of {charged R groups on outside of molecules / composed of many small R groups} ;	- idea of active site R groups enable binding of substrate - idea of hydrophilic on the outside	(3)

Question Number	Answer	Additional Guidance	Mark
* (b)(ii)	(QWC – spelling of technical terms must be correct and the answer must be organised in a logical sequence) 1. idea that drugs would prevent viral replication ; 2. idea that T (helper) {cells / lymphocytes} will not be { killed / burst / destroyed}(by virus particles leaving cell) ; 3. idea of {inhibition / eq} of reverse transcriptase ; 4. idea that (viral) DNA could not be made; 5. from the (viral) RNA ; 6. idea of {inhibition / eq} of integrase ; 7. idea that (viral) DNA cannot integrate into (host) {DNA / genome} / eq ;	QWC emphasis on clarity of expression 1. ACCEPT description of virus formation 3. ACCEPT drugs prevent action of reverse transcriptase 4. reject idea that RNA is {turned into / converted into} DNA 6. ACCEPT drugs prevent action of integrase 7. ACCEPT idea that drugs would prevent {latency / formation of provirus / eq} ;	(5)

Q11.

Question number	Answer	Additional guidance	Mark
	A description that makes reference to four of the following: - stem cell is undifferentiated whereas a 'key player' is differentiated (to undertake a specific function) (1) - example of a 'key player' (1) - example of specific function of a named 'key player' cell (1) - number of divisions of a stem cell is unlimited whereas for a 'key player' the number of cell divisions is limited (1) 'key player' has undergone differential gene expression (1)	ALLOW unspecialised and specialised e.g. B cells / plasma cells / phagocytes / lymphocytes e.g. (B cells) produce antibodies ALLOW Hayflick limit for 'key players' but not for stem cells	Expert (4)

Q12.

Question Number	Answer	Additional guidance	Mark
(i)	A description that makes reference to three of the following: {glycoproteins / GP120} on the (surface of the) virus(1) - bind to (CD4) receptors on the (surface of the) T (helper) cells(1) - viral envelope fuses with cell membrane of T helper cell (1) - viral RNA enters the cell (1)	ALLOW GP130 IGNORE capsid	(3)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to the following • (lack of T helper cells) reduces cytokine production (1) • therefore reducing { cloning / activation } of B cells (1) • reducing antibody production (1) • there is an increased risk of opportunistic infections (1)	ALLOW reduced production of {B effector cells/plasma cells} ALLOW example eg TB	(4)

Q13.

Question Number	Answer	Mark
	The only correct answer is C - preventing the multiplication of bacteria <i>A is not correct because bacteriostatic antibiotics do not destroy bacteria</i> <i>B is not correct because antibiotics are not effective against viruses</i> <i>D is not correct because antibiotics do not prevent the development of antibiotic resistance</i>	(1)

Q14.

Question Number	Answer	Mark
(i)	B - plasma cell <i>The only correct answer is B</i> <i>A is not correct because macrophage does not produce antibodies</i> <i>C is not correct because red blood cells do not produce antibodies</i> <i>D is not correct because T cells do not produce antibodies.</i>	(1)

Question Number	Answer	Mark
(ii)	D – natural passive immunity - the immunity is provided by components of the mother's milk produced as part of a natural immune response. The baby has not produced these components so the immunity is passive. <i>The only correct answer is D</i> <i>A is not correct because the baby has not produced the immunity gained from the mother's milk so it is not active immunity</i> <i>B is not correct because the immunity from the mother was not generated by artificial exposure to antigens (e.g. immunisation) so it is not artificial immunity</i> <i>C is not correct because the baby has not produced the immunity gained from the mother's milk so it is not active immunity</i>	(1)

Q15.

Question Number	Answer	Additional Guidance	Mark
(a)	1. bacteria are cells, viruses are {not / particles} ; 2. idea of bacteria surrounded by {cell wall / slime / capsule} , viruses surrounded by {protein / capsids / envelope} ; 3. bacteria have { plasmids / ribosomes / other named structure} , viruses do not have {plasmids / ribosomes / other named structure} ; 4. bacteria (genome) are DNA, viruses can be DNA or RNA ; 5. bacterial DNA is double-stranded, viral genetic material is single (or double) stranded / eq ; 6. idea that bacteria have {circular / eq} genetic material, viruses have {linear / straight} genetic material ;	NB piece answers together throughout Accept only matched structures 2. Accept for envelope: membrane / phospholipid layer / eq 3. Accept bacteria have membranes, flagella cytoplasm, glycogen, lipid droplets 6. Not in context of plasmid	(3)

Question Number	Answer	Additional Guidance	Mark
(b)(i)	1. reference to humoral (immune) response ; 2. reference to {phagocytosis / eq} by {phagocytes / named phagocyte} ; 3. reference to macrophages as { antigen-presenting cells / APCs} (to T helper cells) ; 4. reference to B cells as { antigen-presenting cells / APCs} (to itself) ; 5. idea that T helper cells release cytokines for B cell {activation / stimulation} ; 6. idea of B cells {forming clones / dividing / eq} (to form B effector cells) ; 7. reference to {differentiation of B cells into plasma cells / formation of plasma cells from B cells} (subsequent to cloning) ;	2. Accept dendritic cells / Langerhans cells / B cells 3 Accept dendritic cells / Langerhans cells 4. Accept antigen binds to B cells 6. Not to form plasma cells	(4)

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	1. reference to {opsonisation / antibodies bind to bacteria / eq} ; 2. (as a result) enhancing phagocytosis / eq ; 3. reference to {immobilisation / agglutination / eq } (of bacteria) ; 4. idea of antibodies neutralising toxins / eq ;	1. Not reference to killing bacteria 2. Accept easier, better	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	1. idea that the immune response will be weaker ; 2. person may not recover from this infection / eq ; 3. idea of {other (opportunistic) infection / cancer} ; 4. reference to cytokines released from {T helper / CD4 } cells ; 5. idea that cytokines are involved in {activation / division } of {B cells / T killer cells} ; 6. credit consequence of impaired B cell function ; 7. credit consequence of impaired T killer cell function ;	1. Accept in context of either humoral or cell-mediated immune response 6. Accept e.g. no antibody produced by plasma cells 7. Accept e.g. infected cells not destroyed	(4)

Q16.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to four of the following: • (cytokines / histamine) increases permeability of the capillaries (1) • (cytokines / histamine) cause vasodilation (1) • increasing blood flow to site of inflammation (1) • allowing white blood cells to { migrate / move } from the blood into the tissue space (1) • cytokines attract white blood cells (1)	ALLOW cause arterioles to dilate MP4 and 5 ALLOW immune cells / phagocytes / macrophages / monocytes ALLOW chemicals in place of cytokines	(4)

Q17.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to three of the following: • {chemical mediators / histamine} released (1) • increasing blood flow / increasing capillary permeability / causing oedema (1) • {increasing number of / activating / recruiting} white blood cells (in the area of inflammation) (1) • (stimulating) the release of (catabolic) enzymes / increasing phagocytosis (of damaged tissue) (1)	ALLOW activating T killer cells / activating phagocytes / activating macrophages ALLOW tissues destroyed by {macrophages / phagocytes / T killer cells}	Expert (3)

Q18.

Question Number	Answer
*	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. • standardisation of composition of compost heaps • identification of species • abundance of each species of organism in the sample • determination of C:N / set up compost heaps with different C:N ratios • time e.g. days / intervals / repetition of sampling • other factors to monitor or control e.g. water / gases / humidity / temperature / aeration / mass • sampling technique e.g. location of sample within compost heap / repetition of sampling

Level	Mark	Descriptor	
0	Marks	No awardable content	
Level 1	1-2	An explanation of how the investigation should be modified may be attempted but with limited analysis, interpretation and/or evaluation of the scientific information. Generalised comments made. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.	Measure / set up compost heaps with different C:N ratios Observe species present over time
Level 2	3-4	An explanation of how the investigation should be modified will be given with occasional evidence of analysis, interpretation and/or evaluation of the scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.	Recording species present / numbers of each species / measuring C:N ratio Monitoring changes over time Control of relevant factors
Level 3	5-6	An explanation of how the investigation should be modified is given which is supported throughout by evidence from the analysis, interpretation and/or evaluation of the scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear, coherent and logically structured.	Description of a suitable sampling technique Linking species present or species density to C:N measurements Use of a statistical test to compare changes of time / C:N ratio Use information on numbers of species and population sizes to demonstrate succession

Q19.

Question Number	Answer	Additional guidance	Mark
(i)	An calculation that shows the following • selection of correct data from table and difference calculated (1) • calculation of percentage to three significant figures (1)	Example of calculation $1855 - 135 = 1720$ 92.7% Correct answer with no working gains full marks.	graduate (2)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to the following • as the vaccination rate increases the number of cases of measles decreases (in some years) (1) • example from data to show why the conclusion is valid (1) • (the effects of changes in percentage vaccination are seen in the following year) because it takes time for {antibodies / memory cells} to be produced (1) • time taken for herd immunity to develop (1)	ALLOW reference to data from specific years such as 2013 to 2014, 2014 to 2015	Expert (4)

Q20.

Question Number	Answer	Mark
(i)	The only correct answer is B <i>produced when B cells are activated to become plasma cells</i> A is not correct because B cells do not become killer cells C is not correct because macrophages do not become B cells D is not correct because plasma cells do not become memory cells	Computer (1)

Question Number	Answer	Mark
(ii)	The only correct answer is A <i>active artificial immunity</i> B is not correct because immunity due to vaccination is not natural immunity C is not correct because passive immunity does not lead to the production of antibodies D is not correct because immunity due to vaccination is not natural immunity and passive immunity does not lead to the production of antibodies	Computer (1)

Question Number	Answer	Additional guidance	Mark
(iii)	An explanation that makes reference to three of the following • due to a loss of memory cells there is no secondary immune response (1) • therefore antibodies cannot be produced quickly (1) • therefore there is less immunity (to diseases previously vaccinated against) (1) • need to repeat vaccinations to produce more memory cells (1)	ALLOW converse for repeat vaccination ALLOW converse for repeat vaccination ALLOW diseases can be contracted that children were previously immune to	Expert (3)

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following • flora in the gut and skin are better adapted to the conditions (1) • therefore they can outcompete pathogenic organisms (1) • bacteria in the gut secrete {chemicals /lactic acid} which help to destroy pathogens (1)	ALLOW details of competition for space or nutrients ALLOW enzymes	(3)

Q22.

Question Number	Answer	Additional guidance	Mark
(i)	A description that makes reference to the following • pre mRNA contains exons and introns (1) • introns are removed and exons are spliced together (to produce a strand of mRNA) (1)	ALLOW reference to introns and exons in the correct context i.e. exons are coding and introns are non-coding regions ALLOW 'joined together' for 'spliced'	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to the following • the {exons can be spliced together in a different order / different exons can be removed } (1) • therefore producing different sequences of amino acids (1)		(2)

Q23.

Question number	Answer	Additional guidance	Mark
	A description that makes reference to four of the following: • extract mRNA for one form of the (tau protein) (1) • copy mRNA into DNA (1) • use restriction enzymes {to create sticky ends} / cut the DNA and a vector} (1) • {ligate / insert / integrate} the TAU DNA into the vector (DNA) (1) • introduce vector into {fertilised egg / embryonic stem / zygote / cells / neural cell stem cells} (1)	IGNORE cut / remove TAU gene from a human ALLOW synthesis DNA sequence for one form e.g. use code specific for one of the tau proteins ALLOW insert gene into fertilised egg cell / embryonic stem cell ALLOW egg cell fertilised after inserting gene	Choose an item. (4)

Q24.

Question Number	Answer	Additional guidance	Mark
(i)	An answer that makes reference to two of the following: • the protein is a receptor in the cell surface membrane of Thelper cells (1) • { glycoprotein / GP120 } is unable to bind with the (CD4)receptor (on the host cell) (1) • viral RNA cannot enter the cell (1)	ALLOW the receptor that HIV binds to ALLOW HIV cannot enter the cell	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to four of the following: • stem cells (from the bone marrow) can differentiate into specialised cells (1) • the stem cells will differentiate into T helper cells that { are resistant to HIV / have the mutated protein } (1) • T helper cells are destroyed by HIV so the patient cannot produce an immune response (1) • mutated (CD4) receptor prevents HIV entering the (replacement) T helper cells (1) • T helper cells are not destroyed therefore { HIV is not present in the blood / AIDS does not develop } (1)		(4)

Q25.

Question Number	Answer	Additional Guidance	Mark
(a)	- idea that {bacteria / pathogen / virus / eq} have to be taken into macrophage / eq ; - idea of fusion of {phagosome / eq} with lysosome ; - idea that {bacteria/ pathogen / virus / eq} are {digested / broken down / eq} (by enzyme) ; - credit named enzyme other than lysozyme ; - idea that part of the {bacteria/ pathogen / virus / eq} has to be on {membrane / (outer) surface} (of the macrophage) ;	- IGNORE phagocytosis unqualified - ACCEPT phagocytic vesicle - IGNORE destroy / killed - e.g. protease - ACCEPT antigen / protein	(4)

Question Number	Answer	Additional Guidance	Mark
(b)	- idea of macrophage {binding/ eq} to T (helper) {cell / lymphocyte} ; - reference to {MHC / major histocompatibility complex } (on macrophage) ; - reference to CD4 (receptor on T cell) ;		(2)

Question Number	Answer	Additional Guidance	Mark
(c)	- idea that a mutation has occurred (in the DNA) ; - idea that there is a change in {antigen /outer surface / cell wall / slime layer} (of bacteria) ; - idea that memory (T) cells will not recognise the (new) antigen ; - idea that another (primary) immune response needed e.g. (new) antigen needs to be presented (to the T helper cell) ; - to activate (another) population of T (helper) cells / eq ; - idea that {phagocytes / macrophages} unable to {recognise / engulf / phagocytose / digest / destroy / eq} the {<i>Mycobacterium tuberculosis</i> / bacteria} ; - idea that antigen presentation is not possible ;	1. NOT a mutation of the antigen	(3)

Q1.

DNA synthesis in bacterial cell cultures has been investigated.

Describe how DNA is organised in a bacterial cell.

(3)

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(Total for question = 3 marks)

Q2.

Describe how DNA profiling could be carried out to show that these snakes are different species.

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(Total for question = 4 marks)

Q3.

Lysozyme is one component of the non-specific response to infection.

Describe what is meant by a non-specific response to infection.

(3)

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Q4.

Describe the changes that occur inside a body in the first week after death.

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(Total for question = 3 marks)

Q5.

Hospitals have developed practices in response to the increase in hospital acquired infections.

Describe the infection control practices hospitals have introduced.

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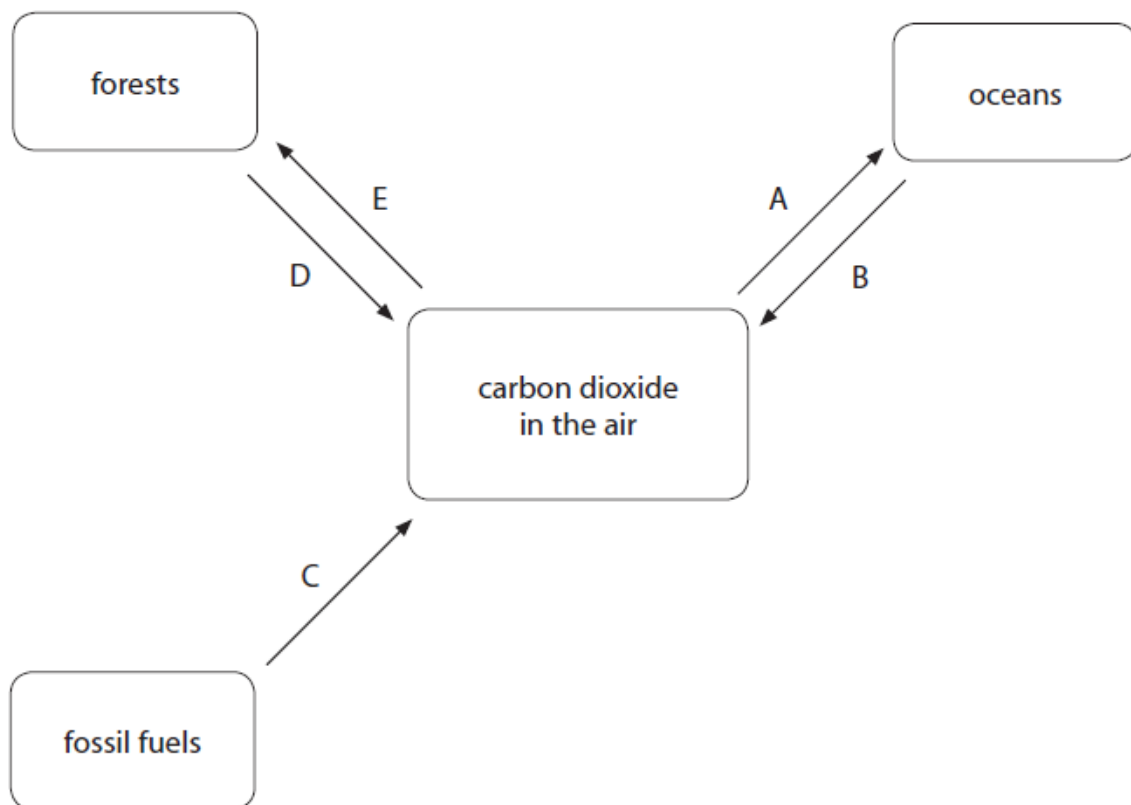
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(Total for question = 3 marks)

Q6.

The diagram below shows part of the carbon cycle. The processes A, B, C, D and E, transfer carbon.



Describe the role of bacteria in process D in the diagram.

(3)

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Q7.

One method of estimating the time of death is to determine the age of blowfly maggots on a dead body.

Microorganisms are also found on a dead body.

Describe the role of decomposers, such as microorganisms, in the carbon cycle.

(2)

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(Total for question = 2 marks)

Q8.

The scientific article you have studied is adapted from several sources.

Use the information from the scientific article and your own knowledge to answer the following questions.

There are 'trillions of microbes' found in the gut, 'as well as others living elsewhere in and on the body'.

Describe the role of the microbes that are normally found on the skin surface of humans (paragraph 40).

(2)

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(Total for question = 2 marks)

Q9.

The skin contains a fibrous protein. This protein forms a barrier to the entry of microorganisms.

(i) Place a cross ☐ in the box next to the name of this protein.

(1)

- ☐ **A** cytokine
- ☐ **B** interferon
- ☐ **C** keratin
- ☐ **D** lysozyme

(ii) The primary structure of a protein is important in determining its final structure and properties.

Describe the structure and properties of fibrous proteins.

(4)

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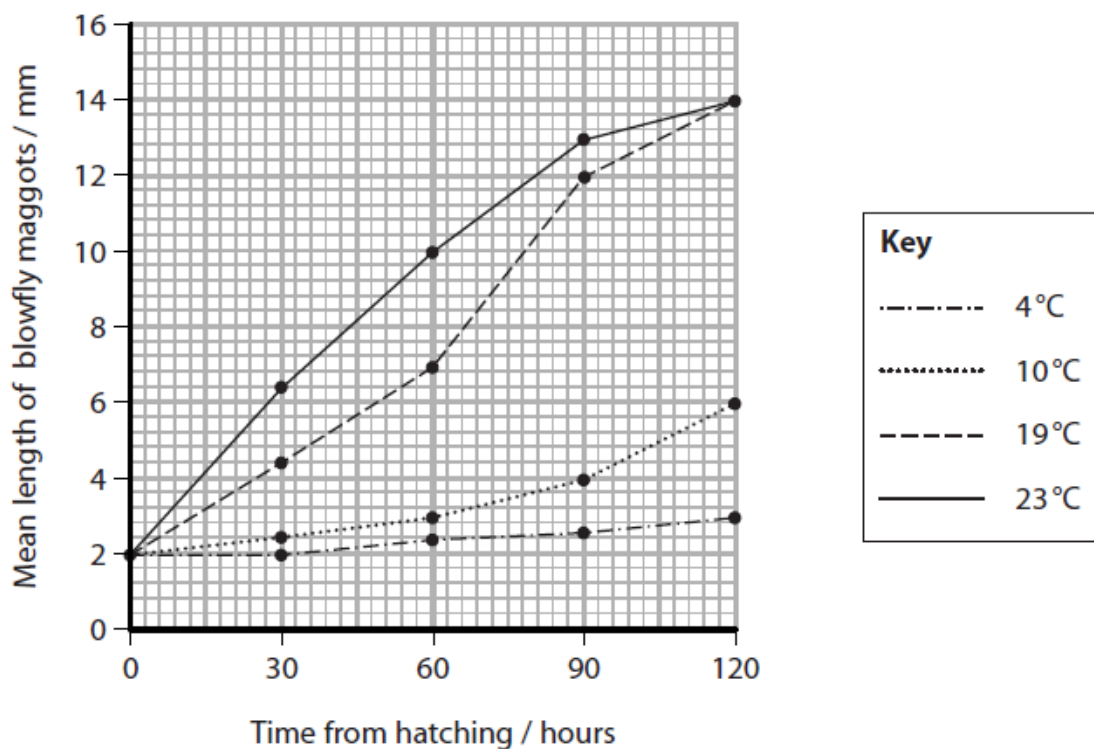
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Q10.

One method of estimating the time of death is to determine the age of blowfly maggots on a dead body.

The effect of environmental temperature on the growth of blowfly maggots is shown in the graph.



(i) Blowfly maggots found on a dead body had lengths between 3 and 8 mm. The body had been at a constant environmental temperature of 19 °C since death.

Determine the maximum time since these maggots hatched.

(1)

..... hours

(ii) Determine the fastest rate of growth of a blowfly maggot at a temperature of 19 °C.

Give your answer to 2 significant figures.

(2)

..... mm hour⁻¹

(iii) Explain the effect of temperature on the rate of growth of blowfly maggots.

(3)

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(Total for question = 6 marks)

Q11.

Skulls can be used as evidence for human evolution.

The only type of human present today is the modern human. In the past, another type of human, called Neanderthal, occupied the same geographical area.

The photograph shows the skulls of both types of human.



Modern human skull

Neanderthal skull

© hairyuseummatt/DrMikeBaxter

Genetic studies now show that these two types of human have interbred.

Only small quantities of DNA can be extracted from the remains of Neanderthal humans.

The quantity of extracted DNA is amplified using

(1)

- ☐ **A** DNA profiling
- ☐ **B** polymerase chain reaction
- ☐ **C** RNA profiling
- ☐ **D** translation chain reaction

Q12.

Grey tree frogs are found in the USA.

The photograph below shows a grey tree frog.



Magnification $\times 1$

Cope's grey tree frog and the eastern grey tree frog are both found in the USA.

These species of grey tree frog are very similar in appearance, but have different mating calls.

A number of scientists believe that the eastern grey tree frog evolved from Cope's grey tree frog during the last ice age.

These species have different numbers of chromosomes in their nuclei. Cope's grey tree frog has two copies of each chromosome. The eastern grey tree frog has four copies of each chromosome. As a result, the cells of the eastern grey tree frog are larger.

(a) The genetic relationship between these two species of grey tree frog has been studied using DNA profiling (DNA fingerprinting).

A small sample of DNA was taken from each species of grey tree frog. This DNA was amplified, fragmented and used to produce a DNA profile (DNA fingerprint) for each species.

*(i) Describe how a DNA profile was produced from this small sample of DNA.

(6)

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(ii) Suggest how these DNA profiles were compared.

(3)

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(b) Scientists in different parts of the USA are investigating the possibility that the difference in cell size is responsible for the different mating calls. This is contributing to an understanding of the evolution of grey tree frogs.

Suggest **two** ways in which the results of their investigations can be shared.

(2)

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Q13.

The Atlantic tomcod is a fish found in the rivers of North America.

The photograph below shows an Atlantic tomcod.



Magnification $\times 1$

Atlantic tomcod in the Hudson River are able to survive high levels of polychlorinated biphenyls (PCBs). PCBs enter the water from industrial processes.

One group of scientists identified a mutation in the DNA of these fish. They found that the AHR2 gene had six bases missing. This mutation was rarely found in Atlantic tomcod in the unpolluted St. Lawrence River.

(a) Suggest how scientists in other countries learnt of these findings.

(2)

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*(b) (i) Describe how the DNA and protein of Atlantic tomcod from the Hudson River could be compared with the DNA and protein of Atlantic tomcod from the St. Lawrence River.

(6)

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(ii) Suggest **one** similarity in the DNA of the Atlantic tomcod from these two rivers.

Give an explanation for your answer.

(2)

[illegible]

(iii) Suggest **one** difference in the protein of the Atlantic tomcod from these two rivers.

Give an explanation for your answer.

(2)

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(Total for question = 12 marks)

Q14.

Skulls can be used as evidence for human evolution.

The only type of human present today is the modern human. In the past, another type of human, called Neanderthal, occupied the same geographical area.

The photograph shows the skulls of both types of human.



Modern human skull

Neanderthal skull

© hairyuseummatt/DrMikeBaxter

Genetic studies now show that these two types of human have interbred.

Explain how the results of electrophoresis could provide evidence for interbreeding between the two types of human.

(2)

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(Total for question = 2 marks)

Q15.

Ebola haemorrhagic fever is a life-threatening disease caused by the Ebola virus.

(a) Explain why antibiotics are not used to treat Ebola haemorrhagic fever.

(2)

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(b) Some of the blood plasma of individuals who have survived infection with Ebola can be collected. This can be used in the treatment of individuals currently infected with Ebola.

Explain why the blood plasma from survivors can be used to treat new cases of Ebola infection.

(3)

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(c) A study of the 2014 Ebola outbreak in Sierra Leone found that the Ebola virus was evolving rapidly.

Explain why the evolution of the virus might reduce the effectiveness of any vaccine being developed.

(4)

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(Total for question = 9 marks)

Q16.

DNA synthesis in bacterial cell cultures has been investigated.

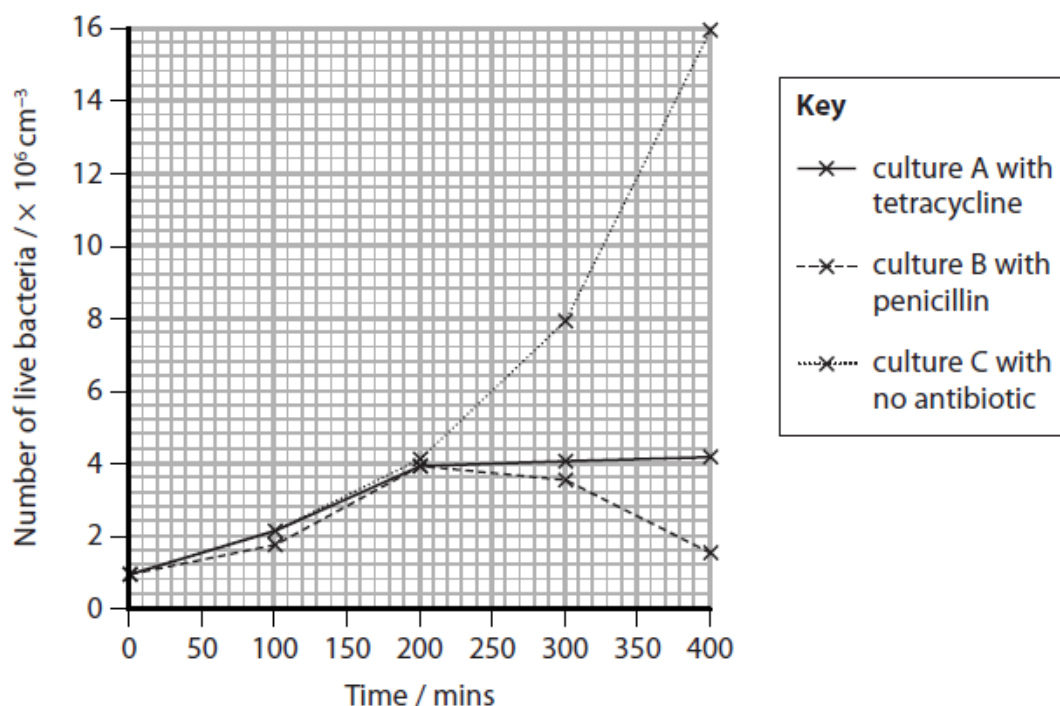
Antibiotics can be used to control bacterial infections.

In an experiment, a culture of bacteria was grown in nutrient broth. The culture was then divided into three separate cultures, A, B and C. The bacterial cultures were grown for 200 minutes.

After 200 minutes the antibiotic tetracycline was added to culture A and the antibiotic penicillin was added to culture B. No antibiotics were added to culture C.

The three cultures were grown for a further 200 minutes.

The results of the experiment are shown in the graph.



Deduce the effects of these antibiotics on the growth of the bacterial cultures.

(2)

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(Total for question = 2 marks)

Q17.

Skulls can be used as evidence for human evolution.

The only type of human present today is the modern human. In the past, another type of human, called Neanderthal, occupied the same geographical area.

The photograph shows the skulls of both types of human.



Modern human skull

Neanderthal skull

© hairyuseummatt/DrMikeBaxter

Genetic studies now show that these two types of human have interbred.

Devise a procedure, using electrophoresis, to compare the amplified DNA from these two types of human.

(4)

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(Total for question = 4 marks)

Q18.

The scientific article you have studied is adapted from *Scientific American*.

Use the information from the scientific article and your own knowledge to answer the following question.

Describe how evasion mechanisms can enable pathogens to become drug-resistant (paragraph 20).

(2)

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(Total for question = 2 marks)

Q19.

A newborn baby can respond to infections.

Inflammation is a non-specific response to an infection.

Explain how changes in the blood vessels result in the redness and swelling seen at the site of inflammation.

(4)

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(Total for question = 4 marks)

Q20.

A deer was found dead on National Trust land. Some people thought that the wounds that led to the deer's death could have been caused by a big cat such as a black panther.



The DNA produced by PCR was analysed to find out if a black panther was involved.

Explain how gel electrophoresis could be used to find out if this DNA came from a black panther.

(5)

This image shows a full page of white paper with horizontal dashed lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting practice. There are no margins, text, or other markings on the page.

(Total for question = 5 marks)

Q21.

The scientific article you have studied is adapted from several sources.

Use the information from the scientific article and your own knowledge to answer the following questions.

'Bacterial molecules pass into the bloodstream where they do not belong, triggering an immune response' (paragraph 32).

Explain how the bacterial molecules could trigger a specific immune response.

This image shows a full page of white paper with horizontal dashed lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting practice. There are no margins, text, or other markings on the page.

(Total for question = 4 marks)

Q22.

The scientific article you have studied is adapted from *The Biologist*.

Use the information from the scientific article and your own knowledge to answer the following question.

Tissue rejection can occur in organs transplanted from other individuals (paragraph 22).

Explain how the immune system is involved in tissue rejection.

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(Total for question = 4 marks)

Q23.

The scientific article you have studied is adapted from *The Biologist*.

Use the information from the scientific article and your own knowledge to answer the following question.

The Zika virus can cause microcephaly. This condition is a result of brain tissue not developing in the foetus (paragraphs 20 and 21).

Explain how the Zika virus can cause microcephaly.

(3)

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(Total for question = 3 marks)

Q24.

The extent of decomposition is important in helping to determine the time of death of a mammal.

Body farms are outdoor laboratories where experiments take place to investigate the changes that take place after death in a range of conditions. Body farms use the bodies of pigs or donated human bodies.

The effects of factors such as temperature, moisture and position of the body on the rate of decomposition can be studied.

Explain the effect of ambient temperature on the rate of decomposition.

(3)

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Q25.

Phagocytosis is a non-specific response of the body to infection.

Explain the meaning of each of the following terms.

(i) Phagocytosis

(2)

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(ii) Non-specific response

(2)

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(iii) Infection

(2)

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Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to three of the following: • (large) circular DNA (1) • DNA not associated with histone proteins (1) • (small / several) plasmids (1) • located in the cytoplasm / not inside a nucleus (1)	ALLOW nucleoid NOT two marks for plasmids are circular DNA	3

Q2.

Question Number	Answer	Additional guidance	Mark
	A description that makes reference to four of the following: - DNA obtained from the two types of grass snake (1) { PCR / restriction enzymes } used to produce fragments of DNA (1) - gel electrophoresis used to analyse the DNA samples (1) (gel electrophoresis) used to separate the fragments of DNA (1) - more differences in the pattern of bands produced would indicate that the snakes are different species (1)	ALLOW produce different length sections of DNA or target regions of DNA ALLOW description of gel electrophoresis e.g. use of agarose gel and electric current ALLOW similar patterns in the bands would indicate they are the same species	(4)

Q3.

Question Number	Acceptable Answer	Additional Guidance	Mark
	A description that makes reference to the following: - response that is effective against (wide) range of infectious agents (1) - does not involve recognition of infectious agent (1) - does not react to specific antigens (1)		(3)

Q4.

Question Number	Answer	Additional guidance	Mark
	A description that makes reference to three of the following: • (body) temperature falls (1) • rigor mortis / stiffening of the muscles (1) • autolysis / break down of cells by enzymes in the body (1)	ALLOW algor mortis ALLOW breakdown of tissues by enzymes ALLOW accumulation of gases	(3)

Q5.

Question Number	Answer	Additional guidance	Mark
	A description that makes reference to three of the following: • hand wash (stations) (1) • (doctors / nurses) not to wear { ties / watches / long sleeves } (1) • testing patients for the presence of antibiotic resistant bacteria before admission / {isolation / quarantine} of infected patients (1) • increased washing of bedding / disinfection of { beds / surfaces } (1)	ALLOW antibacterial / antiseptic / alcohol gel / hand sanitisers ALLOW use of disposable bedding	(3)

Q6.

Question Number	Answer	Additional Guidance	Mark
	1. decomposition / idea of breakdown of {organic matter / plant material / biomass / eq} ; 2. idea of (bacteria) producing {enzymes (for digestion) / correctly named hydrolytic enzyme} ; 3. respiration {produces / eq} {carbon dioxide / eq} ;	1 ACCEPT animal material decay / rot	(3)

Q7.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to two of the following: - decomposers break down organic material (from the dead body) (decomposers) respire - releasing carbon dioxide (into the atmosphere)	ALLOW organic molecules / named organic molecule / organic compounds ALLOW respiration takes place ALLOW methane in context of anaerobic respiration	(2)

Q8.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to two of the following: • (skin flora) {prevents / reduces } colonisation by other microbes (1) • make environment hostile for other microbes (1) • outcompetes other microbes (1)	ALLOW {bacteria / pathogenic bacteria / pathogens} for other microbes e.g. produce { lactic acid / lactate }	(2)

Q9.

Question Number	Answer	Additional Guidance	Mark
(i)	C keratin		(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	1. idea of little {tertiary / quaternary } structure / eq OR mainly secondary structure ; 2. made up of {long / linear / straight / eq} {molecules / (poly)peptides / polymers }; 3. idea of cross-linking (between one polypeptide chain and another) ; 4. idea of repeating amino acid sequences / eq ; 5. insoluble / eq ; 6. tough / strong / eq ;	3 NOT peptide bonds 5 IGNORE hydrophobic on outside	(4)

Q10.

Question Number	Answer	Additional Guidance	Mark
(i)	66	ALLOW 67	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	- correct values taken from the graph - correct rate calculated from figures used from graph	<u>Example of calculation</u> $(12 - 6.8) \div (90 - 60) =$ or $5.2 \div 30 =$ ALLOW 5.0, 5.1 or 5.2 0.17 (mm hour ⁻¹) (0.1667 or 0.167 – one mark only) Correct answer without working gains full marks	(2)

Question Number	Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to the following: - temperature affects {enzymes / metabolism / reactions} - an increase in temperature increases kinetic energy - producing more (frequent) collisions between enzyme and substrate (molecules) (1)	ALLOW protein synthesis / cell division ALLOW converse statement for temperature decrease ALLOW more (frequent) formation enzyme-substrate complexes	(3)

Q11.

Question Number	Answer	Mark
	The only correct answer is B polymerase chain reaction <i>A is not correct because it is not profiling</i> <i>C is not correct because it is not RNA</i> <i>D is not correct because it is not translation</i>	(1)

Q12.

Question Number	Answer	Additional Guidance	Mark
* (a)(i)	(QWC – spelling of technical terms must be correct and the answer must be organised in a logical sequence) - multiple copies of DNA made / eq ; - using {PCR / <i>polymerase chain reaction</i>} ; - credit any correct detail of PCR ; - reference to <i>restriction</i> {<i>enzymes</i> / <i>endonucleases</i>} to produce DNA {<i>fragments</i> / eq} ; - reference to (<i>gel</i>) <i>electrophoresis</i> ; - idea of {loading / eq} the DNA onto the {<i>gel</i> / named <i>gel</i>} ; - idea that an {<i>electric current</i> / charge} is applied ; - reference to use of {<i>dye</i> / <i>fluorescent tag</i> / <i>UV light</i> / <i>Southern blotting</i> / <i>gene probes</i> / <i>radioactive labelling</i> / eq} ;	QWC emphasis on spelling - IGNORE refs to amplification, large amounts - e.g. step 1: 90 to 95 °C, step 2: 50 to 65 °C, step 3: 70 to 80 °C, use of {<i>primers</i> / DNA <i>polymerase</i> / <i>nucleotides</i>}, many repetitions - e.g. <i>agarose</i>, <i>agar</i> - ACCEPT apply <i>potential difference</i>	(6)

Question Number	Answer	Additional Guidance	Mark
(a)(ii)	- idea of comparing total number of {bands / eq} ; - idea of comparing position of {bands / eq} ; - idea of comparing {size / width} of {bands / eq} ;	ACCEPT idea of comparing bands for 1 mark if mps 1, 2 or 3 cannot be awarded ACCEPT bars / blocks	(3)

Question Number	Answer	Additional Guidance	Mark
(b)	{scientific / peer reviewed} {papers / journals / magazines / article} ; (scientific) {conferences / lecture / forums} ; - media reports ;	3. e.g. TV, radio, newspaper, internet	(2)

Q13.

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	1. same number of chromosomes ; 2. idea that the mutation affected the sequence of DNA ; OR 3. idea that (all / most of) the {bands / eq} are the same (size / position / width) ; 4. idea that only {a small region of DNA / the AHR2 gene} is affected ;	1. ACCEPT both contain AHR2 gene	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	1. a protein with a different {structure / amino acids / function} / eq ; 2. idea that the mutation will affect the DNA ;	1. ACCEPT two AAs missing 2. e.g. two codons missing	(2)

Q14.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following - by comparing the {location / number of} bands produced by the two types of DNA (1) - similarities would indicate interbreeding (in the past) (1)	ALLOW a description eg looking whether the bands are next to each other	(2)

Q15.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	An explanation that makes reference to the following: - antibiotics target { organelles / structures / processes } found in bacteria (1) - viruses therefore unaffected by antibiotics (1)		(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)	An explanation that makes reference to the following: - survivors will have antibodies specific to the virus in their plasma (1) - antibodies given to individuals infected with Ebola will provide passive immunity (1) - the antibodies provided will		(3)

Question Number	Acceptable Answer	Additional Guidance	Mark
	therefore (1) { agglutinate / opsonise } the virus particles		

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)	An explanation that makes reference to the following: - vaccine stimulates immune response to make antibodies specific to viral proteins (1) - mutations in the virus nucleic acid (1) - results in a change in the shape of the viral proteins (1) - therefore antibodies can no longer bind to the virus (1)	Accept reference to antigens Ebola is an RNA virus but allow reference to mutations in DNA	(4)

Q16.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following: - tetracycline { is bacteriostatic / stops bacteria dividing } (because the number of bacteria stays the same) (1) - penicillin {is bactericidal / kills bacteria } (because the number of bacteria decreases) (1)		2

Q17.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to four of the following • restriction { enzymes / endonucleases } used to cut DNA (from modern humans and Neanderthals) into fragments (1) • DNA samples are loaded onto (agarose) gel (1) • {electric current is passed through / potential difference is applied across} the gel (1) • markers are added to visualise the bands (1) • the position of the bands produced can be compared (1)	ALLOW use of fluorescent dyes	(4)

Q18.

Question number	Answer	Additional guidance	Mark
	A description that makes reference to two of the following: • (accumulation of) mutations resulting in change in target recognised by host (1) • transfer of genetic material coding for resistance genes (1) • example of a resistance mechanism (1)	ALLOW mutations result in change in shape of antigens ALLOW transfer of plasmids between bacteria e.g. enzyme / change in shape of receptor binding protein / TB mechanisms, waxy coat / virus using host cell membrane	Expert (2)

Q19.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to four of the following: - histamine is released (histamine) causes {arterioles to dilate/ vasodilation} - which increases the blood flow (to the site causing redness) (histamine) also causes the permeability of capillaries to increase - allowing blood plasma to {leave the capillary / enter the tissues} (causing oedema / swelling)	ALLOW reference to 'leaky' capillaries	(4)

Q20.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to five of the following: - detail of loading of electrophoresis tank (1) { current / potential difference } applied across the gel (1) - use { gene probe / DNA stain } (1) - use of { STRs / DNA } of black panther (1) - compare { bands / DNA profiles } (1) - a match would indicate that (DNA from) a black panther was present (1)	e.g. use of agarose gel, use of a buffer, sample placed in wells ALLOW voltage e.g. fluorescent dye, methylene blue, iodine or ethidium bromide ALLOW reference to Southern blot technique ALLOW compare lines	(5)

Q21.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to four of the following: • bacterial molecules are engulfed by { macrophages / phagocytes / B cell } (1) • antigen presented on the surface of cell / antigen presenting cell produced (1) • T (helper) cells with complementary { CD4 / receptor } bind to APCs (1) • cytokine released causes { cloning of B cells / formation of B effector cells } (1) • plasma cells { produce / release } antibodies (1)	ALLOW reference to antigens on MHCs ALLOW APC	(4)

Q22.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to four of the following: • (donated) { proteins / cells / tissues / organs } act as antigens (1) • (which are) presented by { macrophages / phagocytic cells / antigen presenting cells } (1) • (leading to) activation of T helper cells (1) • (leading to) activation of { T killer cells / cytotoxic T cells / B cells / plasma cells to produce antibodies } (1) • (resulting in) destruction of the transplanted tissue (1)	ALLOW { proteins / cells / tissues / organs } are recognised as being foreign ALLOW cells { destroyed / marked for destruction }	(4)

Q23.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to three of the following: • virus binds to receptors on (neural) cells (1) • { virus / genetic material } is taken into the cell (1) • virus replicates (1) • causing (neural) cells to {die / burst} / inhibiting replication of (neural) cells / spreads to other (neural) cells (1)	(It must be clear that the answer refers to either neural cells or brain cells to gain the first or last marking point) IGNORE viral DNA / RNA replicated IGNORE virus reproduces	(3)

Q24.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following • an increase in temperature will increase the rate of { decomposition / decay } (1) • (an increase in temperature) increases enzyme activity (1) • an increase in temperature increases growth rate of {bacteria / fungi / decomposers} (1)	ALLOW converse for all points for the effects of a decrease in temperature ALLOW high temperatures may denature enzymes and decrease rate of decomposition ALLOW increases rate of multiplication	(3)

Q25.

Question Number	Answer	Additional Guidance	Mark
(i)	1. idea of binding of {bacteria / virus / pathogen / microorganism / antigen / non-self / foreign matter / eq} to (phagocytic) cell ; 2. idea that {bacteria / virus / pathogen / microorganism / antigen / eq} is {engulfed by / taken into / endocytosis into } (phagocytic) cell ; 3. idea of bacteria being inside a {vacuole / phagosome / eq} ;	1 ACCEPT phagocyte 2 ACCEPT phagocyte 3 ACCEPT vesicle	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	1. idea that the body {reacts / defends itself / responds /eq } to a {bacteria / virus / pathogen / microorganism / antigen / non-self /	1 NOT reference to immune response 2 ACCEPT	(2)

Question Number	Answer	Additional Guidance	Mark
	foreign matter / eq} ; 2. idea that the response is not dependent on the specific {bacteria / virus / pathogen / microorganism / antigen / eq} ; 3. credit named reaction e.g. lysozymes , inflammation, phagocytosis, interferon production ;	idea of no previous infection / responds to any pathogen 3 IGNORE egs of barriers	

Question Number	Answer	Additional Guidance	Mark
(iii)	1. reference to {bacteria / virus / pathogen / microorganism / eq} ; 2. being inside {tissues / cells } / eq ;	1 IGNORE disease / infection / foreign matter / antigen 2 IGNORE body ACCEPT idea that has evaded barriers, named cell or tissue IGNORE {infects / attaches / harms / attacks} cells	(2)