PEARSON EDEXCEL A-LEVEL BIOLOGY A · 9BN0

BIOLOGY



EXAM QUESTION PACK

TOPIC 6: IMMUNITY, INFECTION AND FORENSICS

SCORE	PERCENTAGE
/632	%

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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 ×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.

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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

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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.

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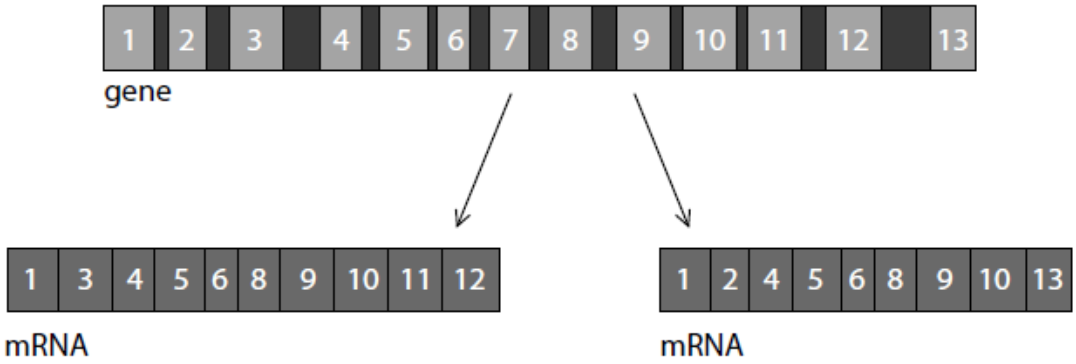
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(Total for question = 4 marks)

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)

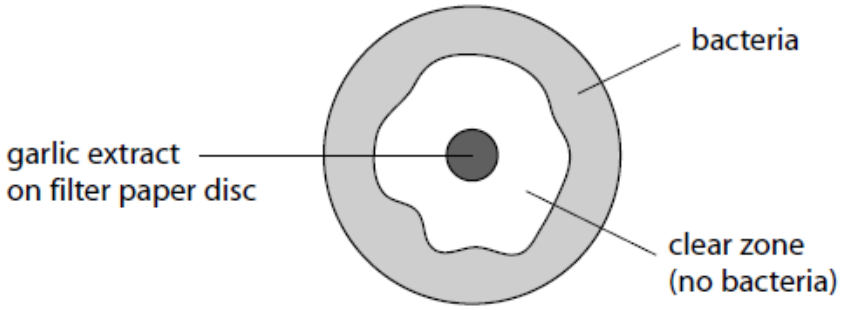
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(ii) The diagram shows the effect of the garlic extract on bacteria growing on an agar plate.



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 / mm²			
	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:

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

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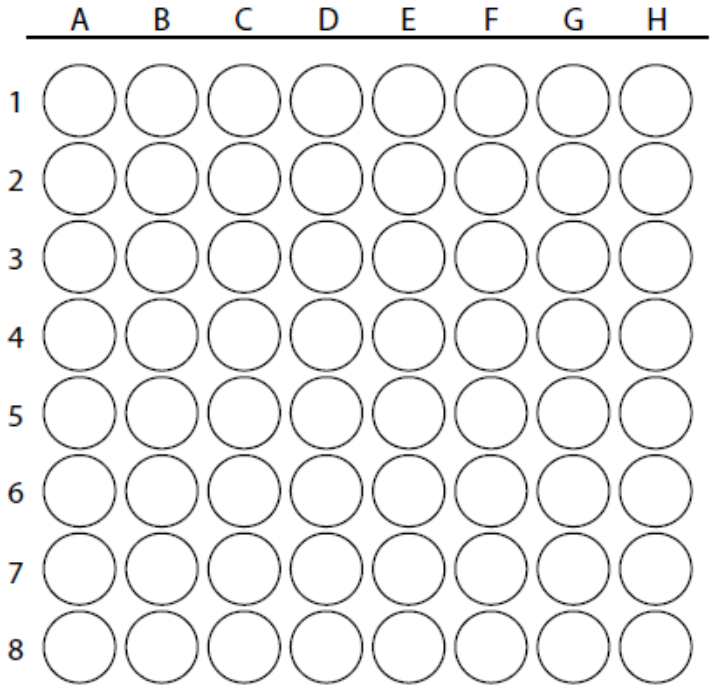
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(c) The size of the clear zone depends on variables other than the antibacterial properties of the substances used, such as size and solubility of the antimicrobial molecules in the extract.

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

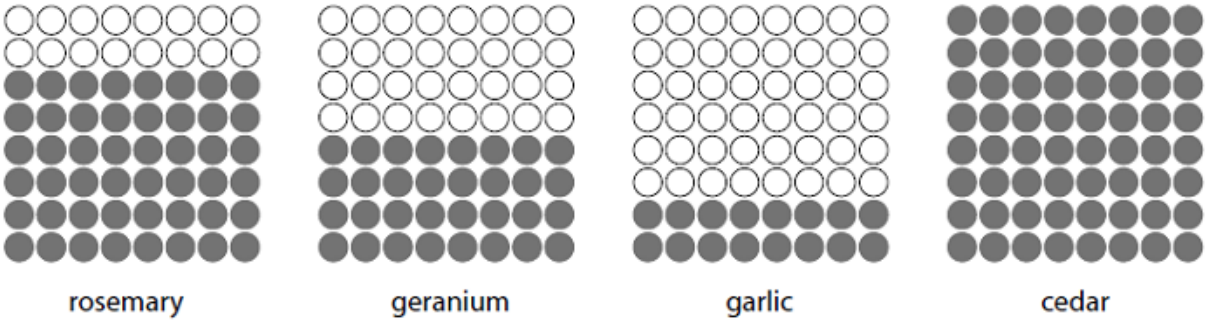
Samples of extract, bacteria (*E. coli*) and a respiration indicator were placed in a micro-titre tray.



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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(Total for question = 20 marks)

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.

Devise a laboratory procedure to compare the effectiveness of penicillin with one of the new antibiotics.

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(Total for question = 11 marks)

Q8.

Human papilloma virus (HPV) is a DNA virus.

Cervarix and Guardasil 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).

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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.

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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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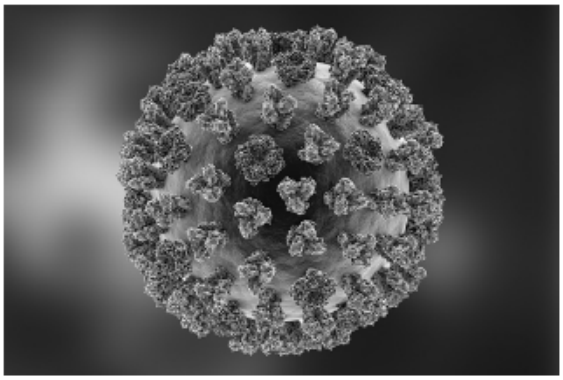
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(Total for question = 2 marks)

Q12.

The diagram shows an RNA virus that causes influenza.

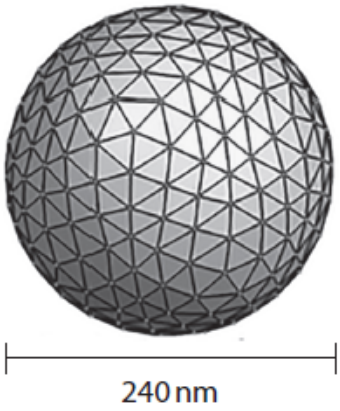


(Source: © Kateryna Kon/Shutterstock)

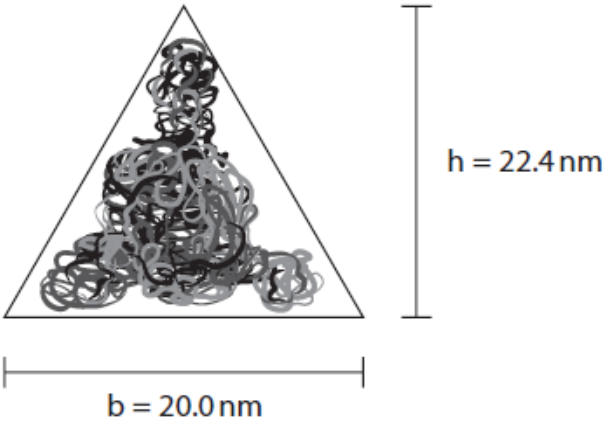
The surface of this virus capsid is covered with 'spike' proteins.

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 $\frac{h \times b}{2}$

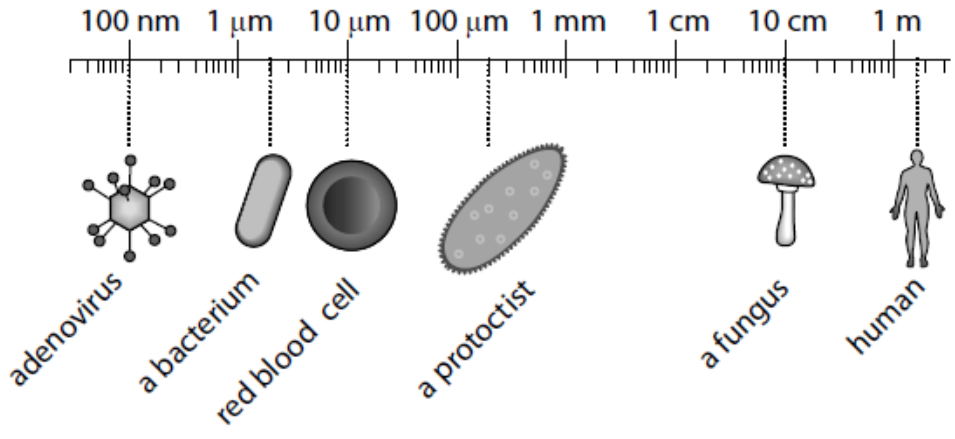
(3)

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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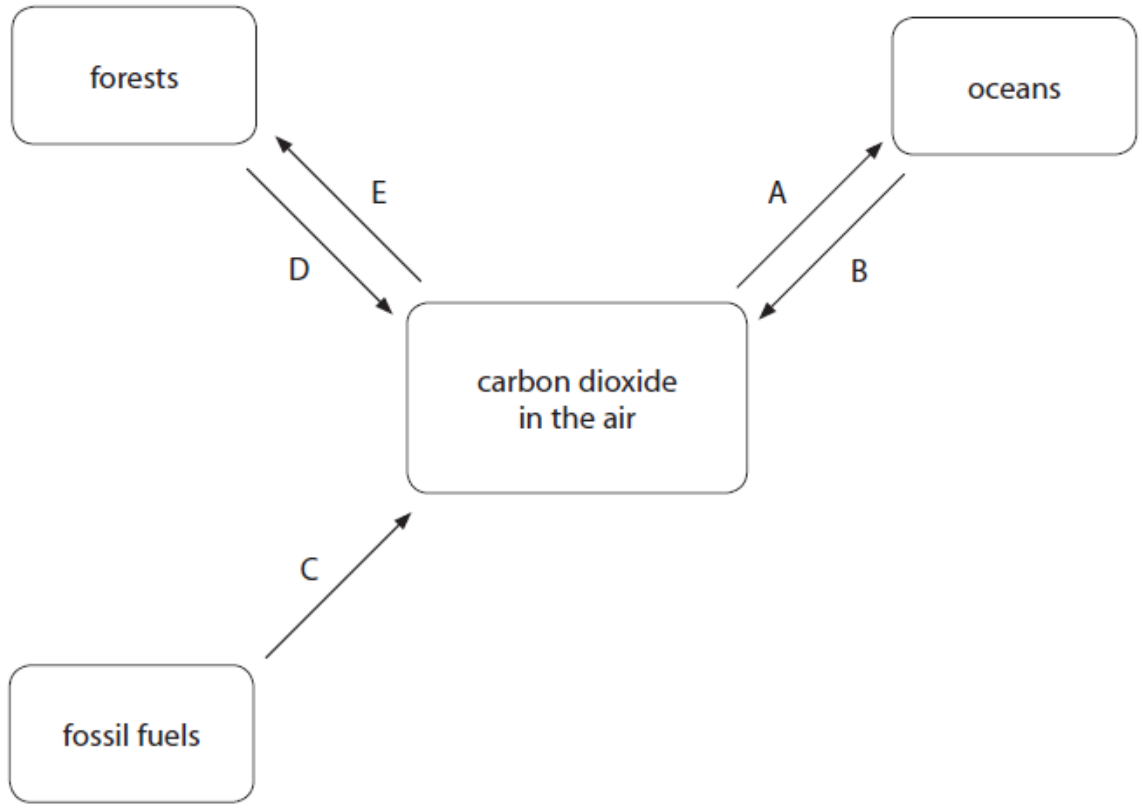
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(Total for question = 2 marks)

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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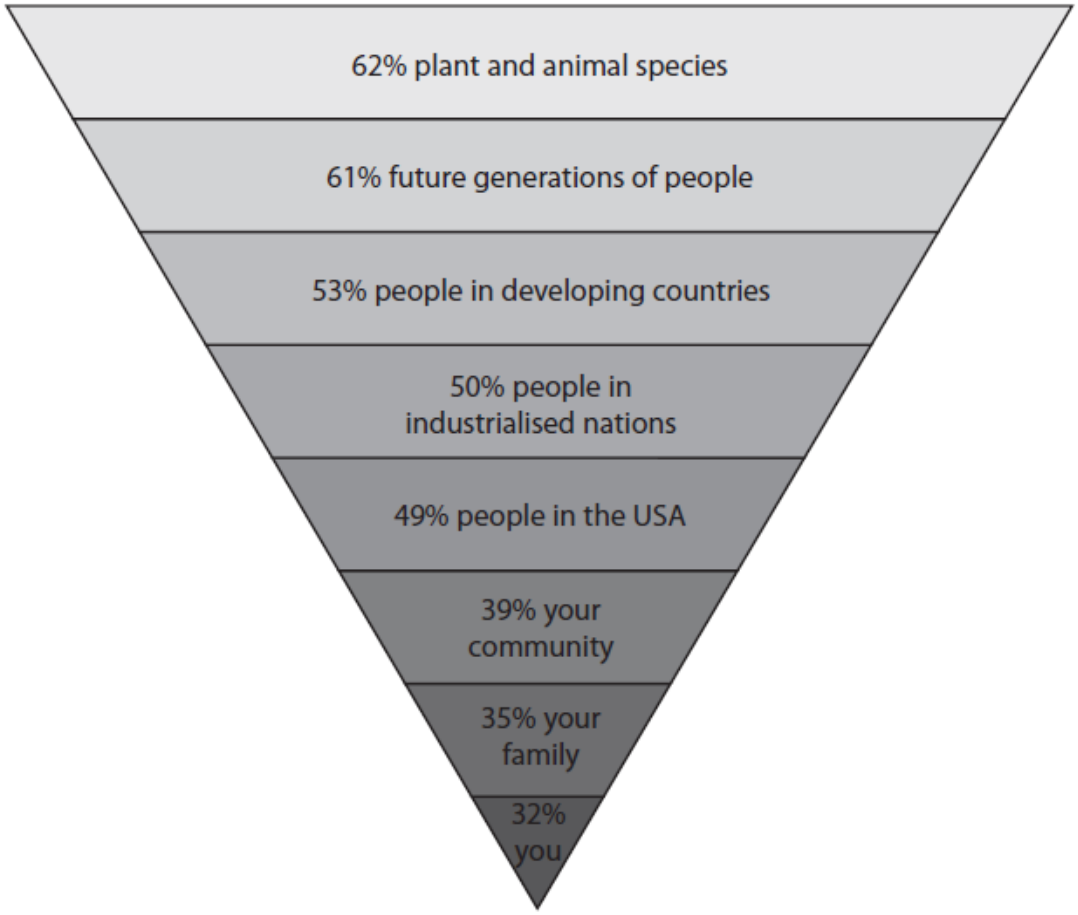
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Q17.

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.

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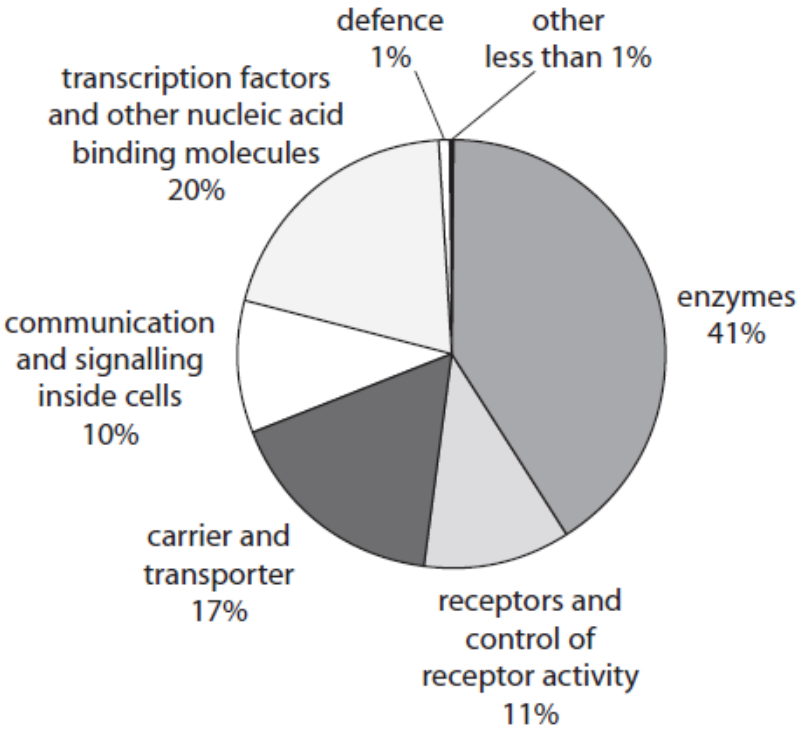
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(Total for question = 1 mark)

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.

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

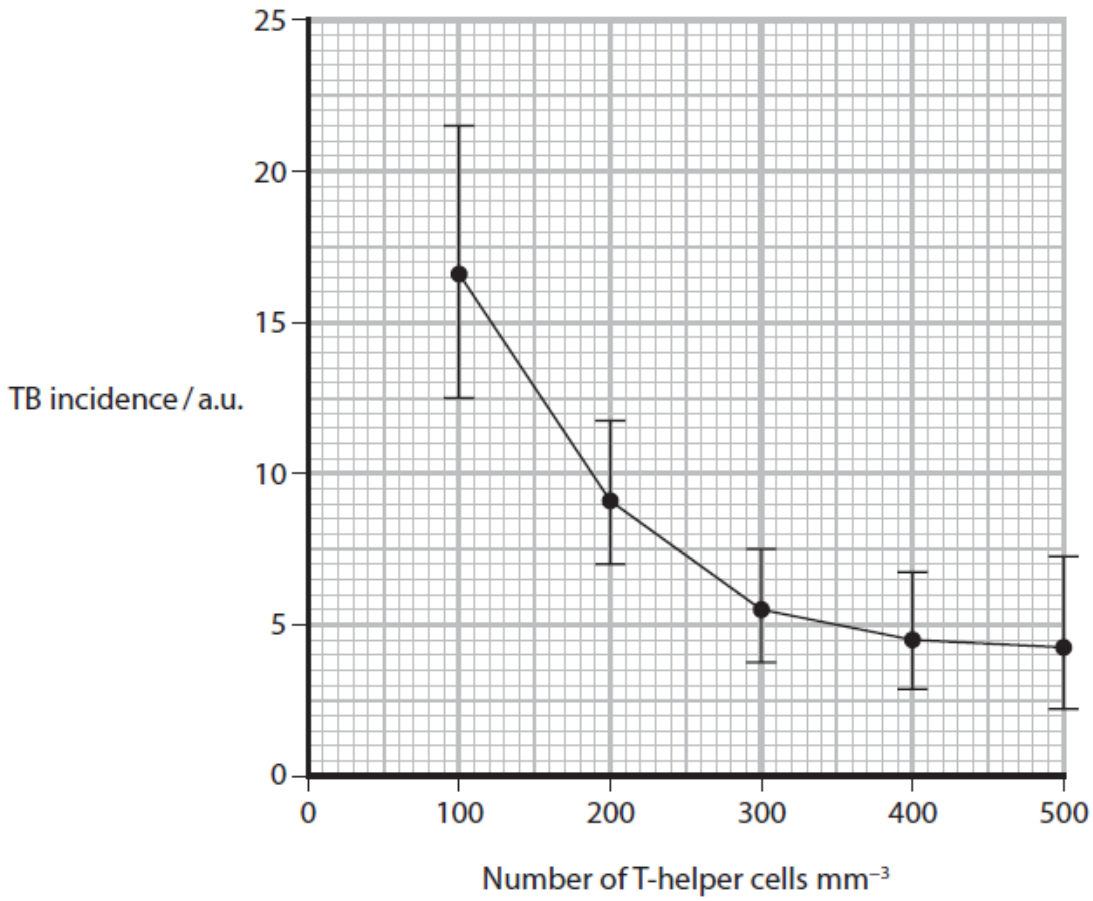
The table shows data for deaths worldwide from HIV and TB in 2016.

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.

(6)

(Total for question = 10 marks)

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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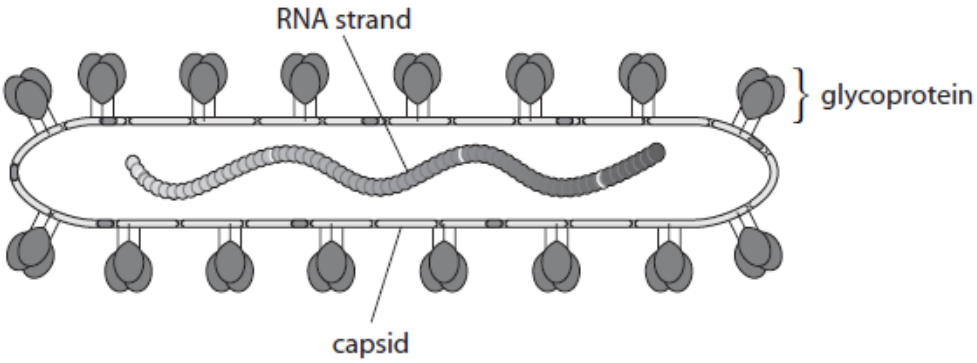
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(Total for question = 4 marks)

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)

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.

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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.

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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.

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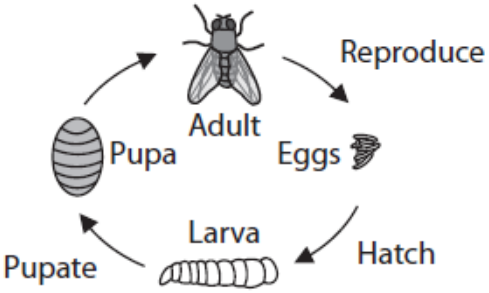
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(Total for question = 5 marks)

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 (rs) using the equation:

(3)

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

where $\Sigma d^2 = 34$ 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.

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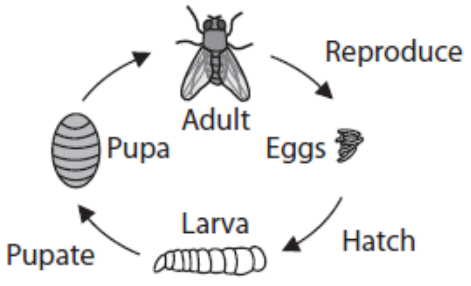
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(Total for question = 8 marks)

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 ± 1.1 °C
- mean temperature of the air surrounding the rhinoceros was 33 ± 3.0 °C.

(i) Determine how the mean temperature of 49 °C was found.

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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.

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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.

(3)

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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

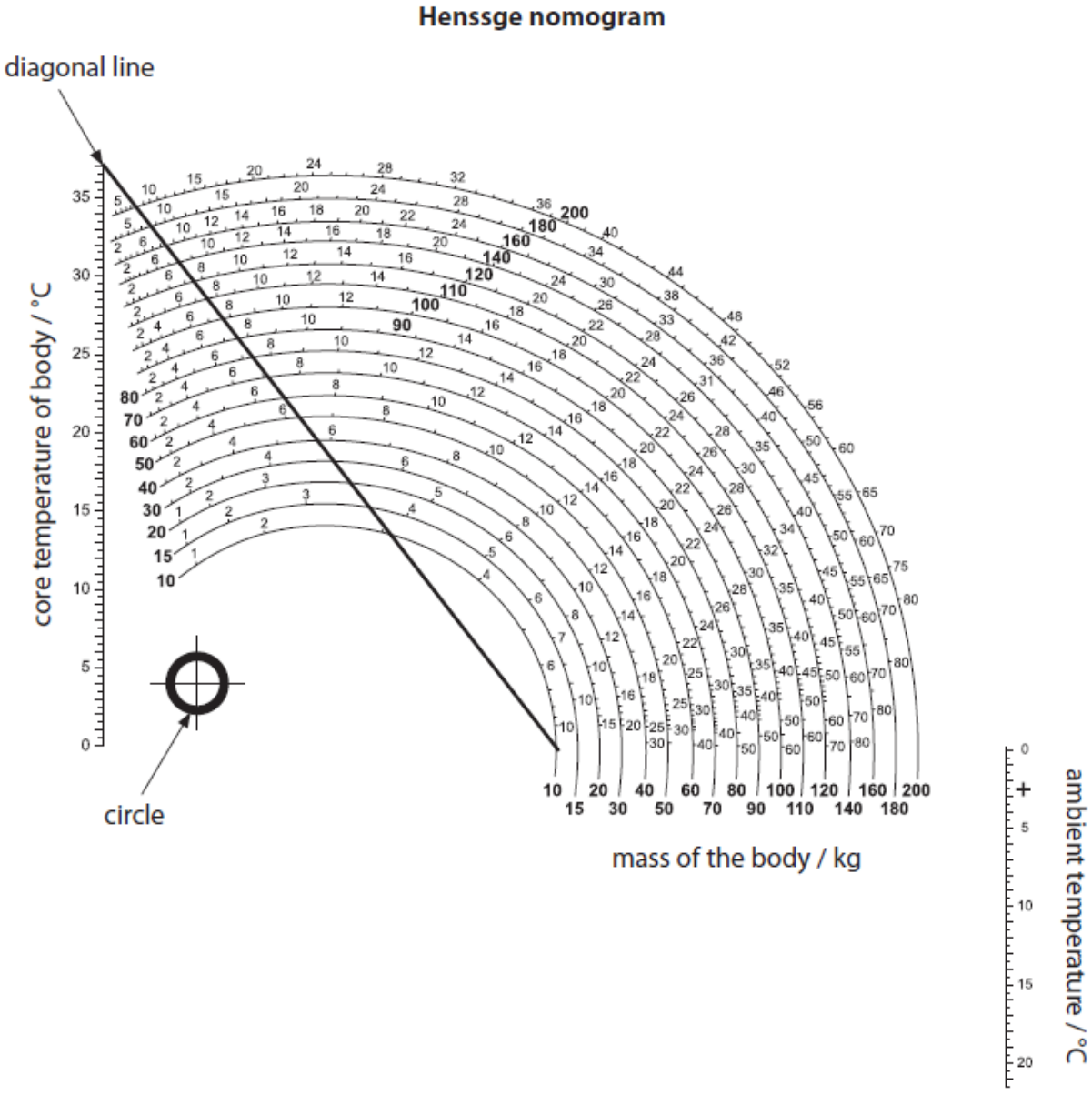
Draw a straight line between the core temperature of the body and the ambient temperature (= line 1)

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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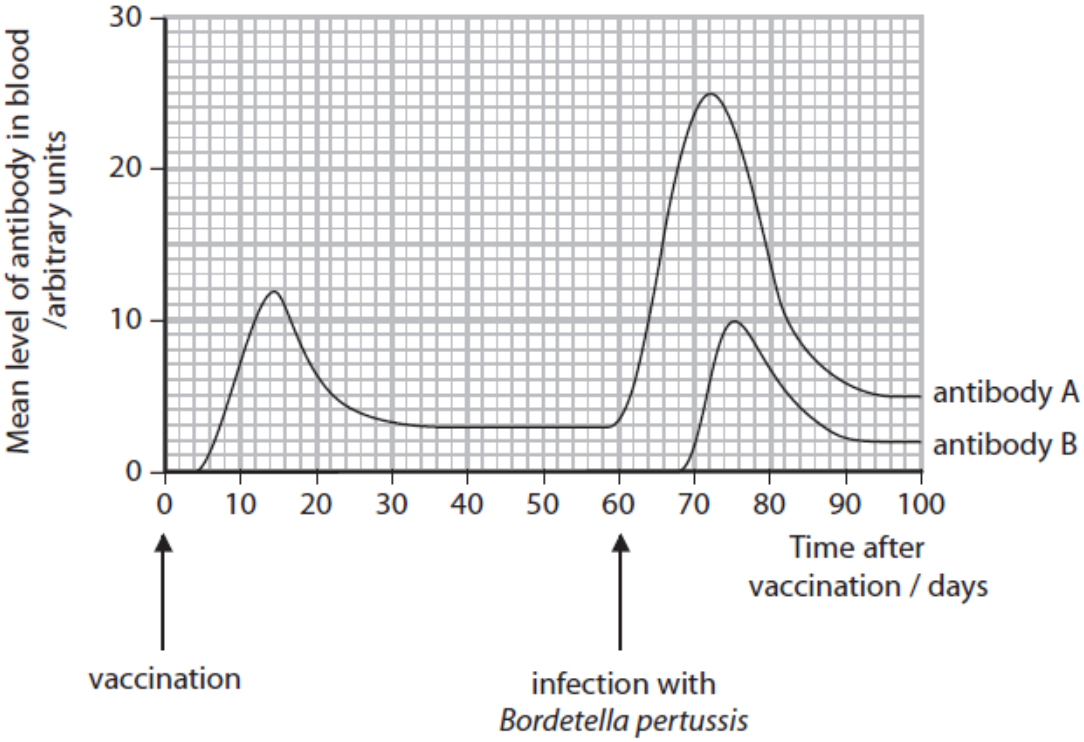
Q7.

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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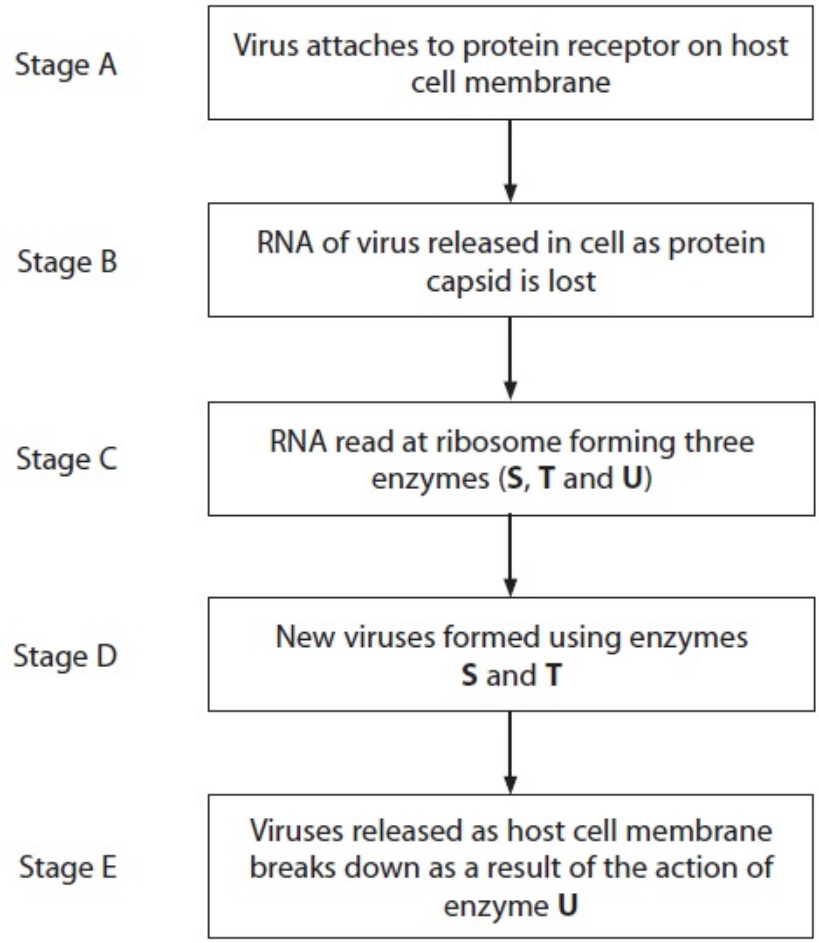
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(Total for question = 4 marks)

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.

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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.

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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.

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(Total for Question = 11 marks)

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 α4β1 integrin projects out from the cell surface membrane of white blood cells.

Deduce how molecules such as α4β1 integrin help immune cells cross the blood-brain barrier (paragraph 8).

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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.

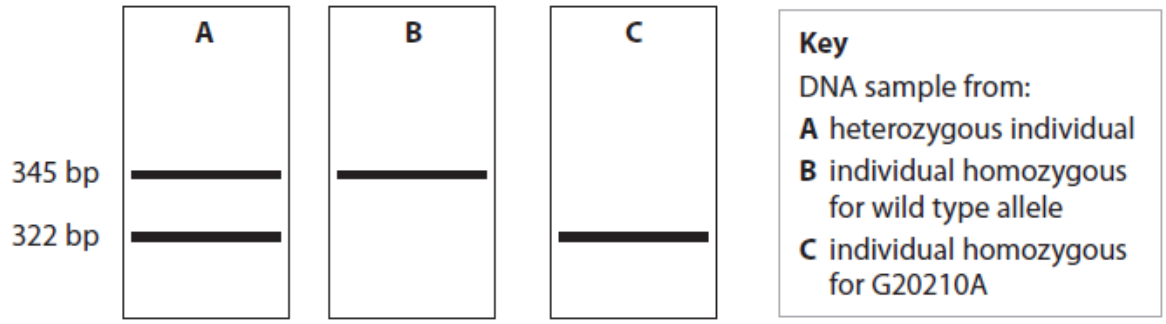
Individuals with a family history of DVT may be offered a genetic test for the G20210A allele.

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.

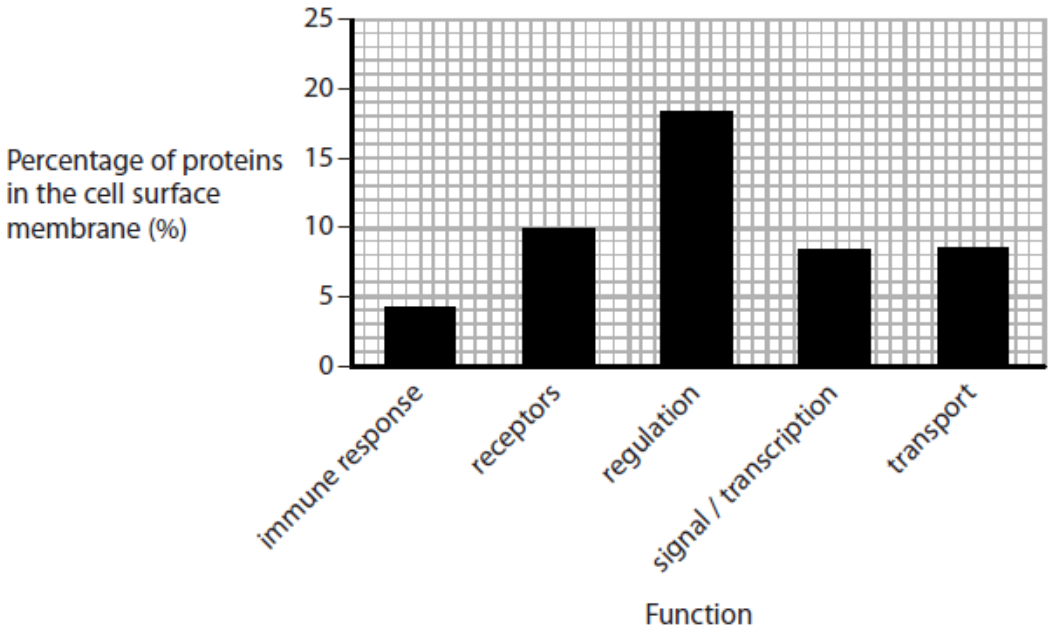
Scientists have studied the proteins present within human cells. Proteins in a cell are found in several locations.

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.

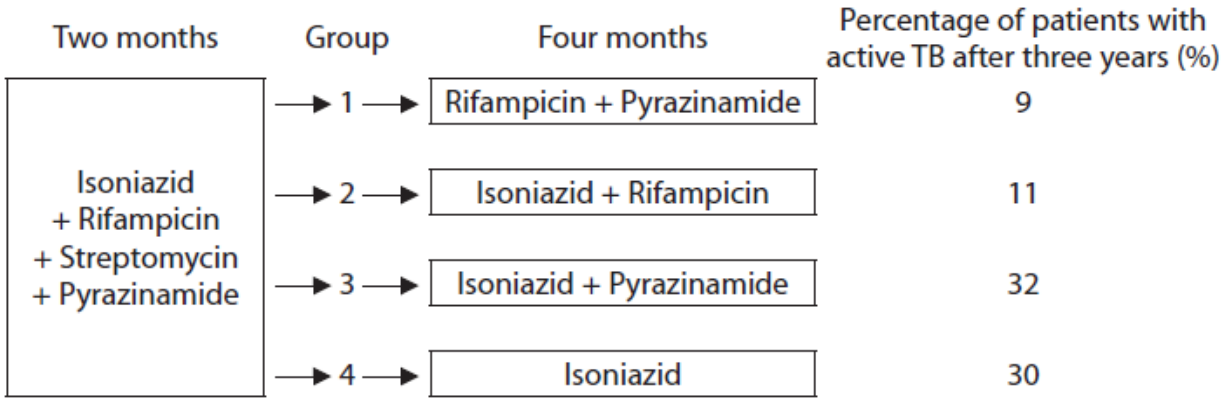
Antibiotic	Mechanism of action
Isoniazid	Inhibits the synthesis of a fatty acid needed to make bacterial cell walls
Rifampicin	Inhibits bacterial RNA polymerase
Streptomycin	Binds to bacterial ribosomes to prevent the binding of tRNA
Pyrazinamide	Not yet known, but not the same mechanisms as the other 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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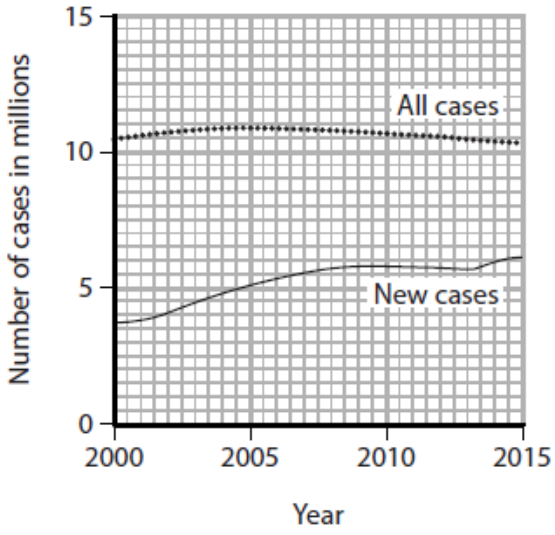
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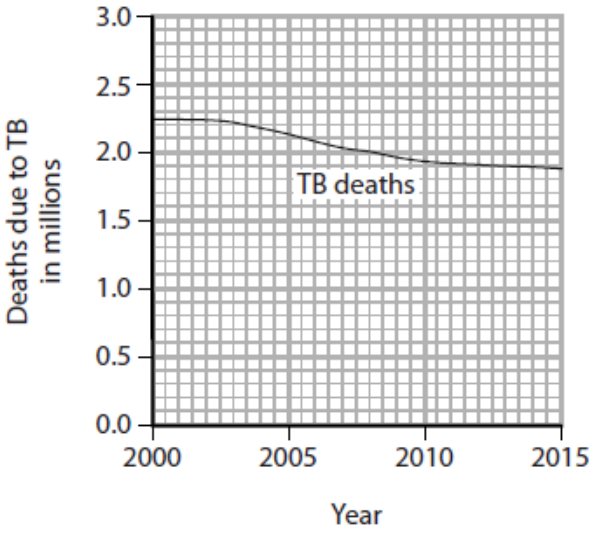
(Total for question = 6 marks)

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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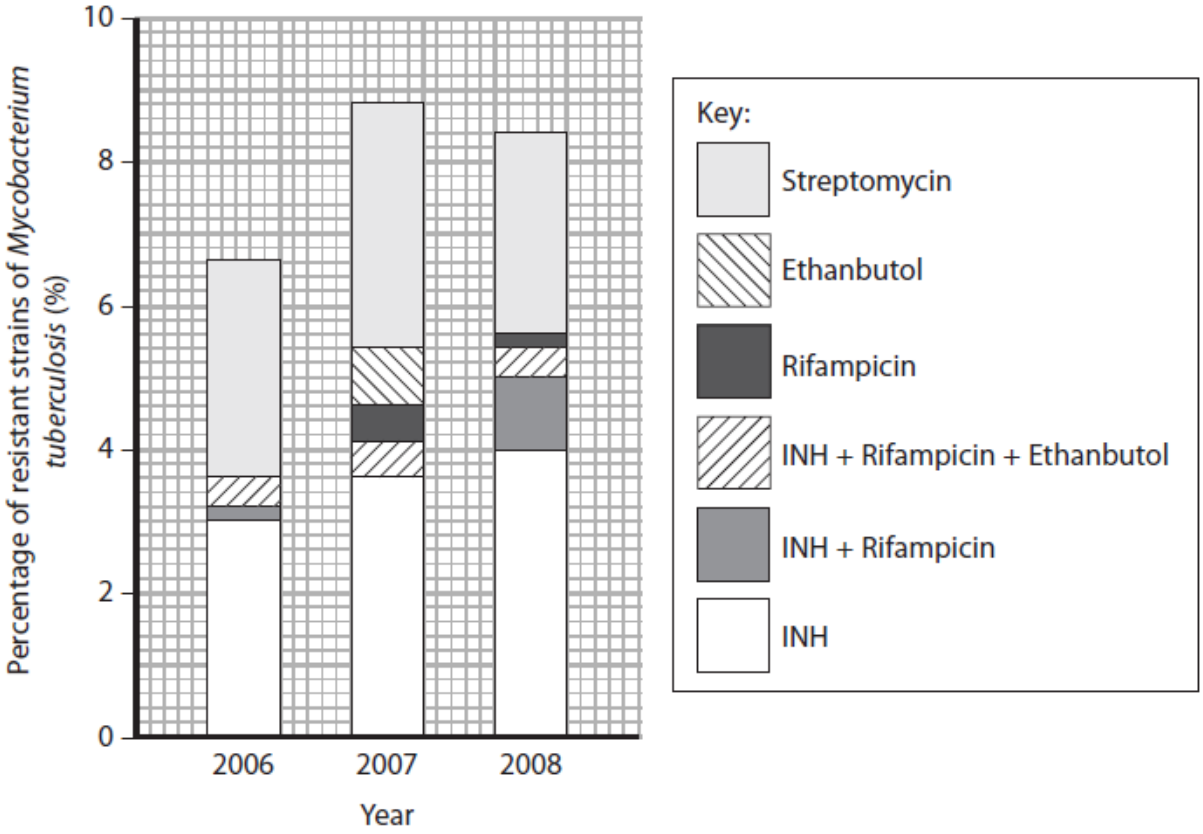
(Total for question = 3 marks)

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.

(3)

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

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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.

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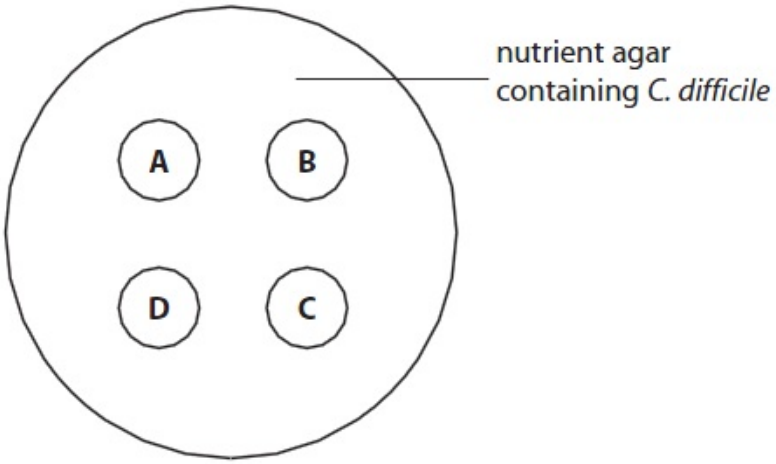
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(b) An investigation of the effectiveness of different antibiotics on *Clostridium difficile* was carried out by a hospital laboratory. Several nutrient agar plates, containing *C. difficile*, were prepared.

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.

(3)

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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)

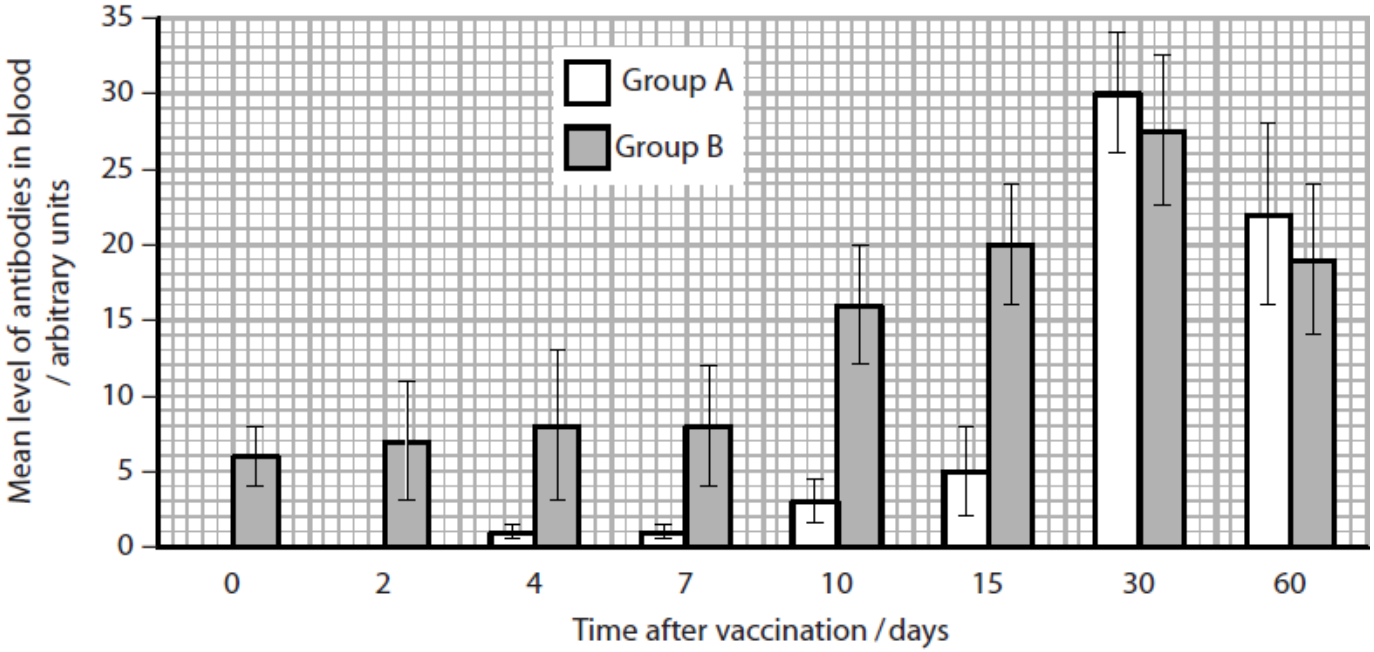
Q8.

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.

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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.

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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.

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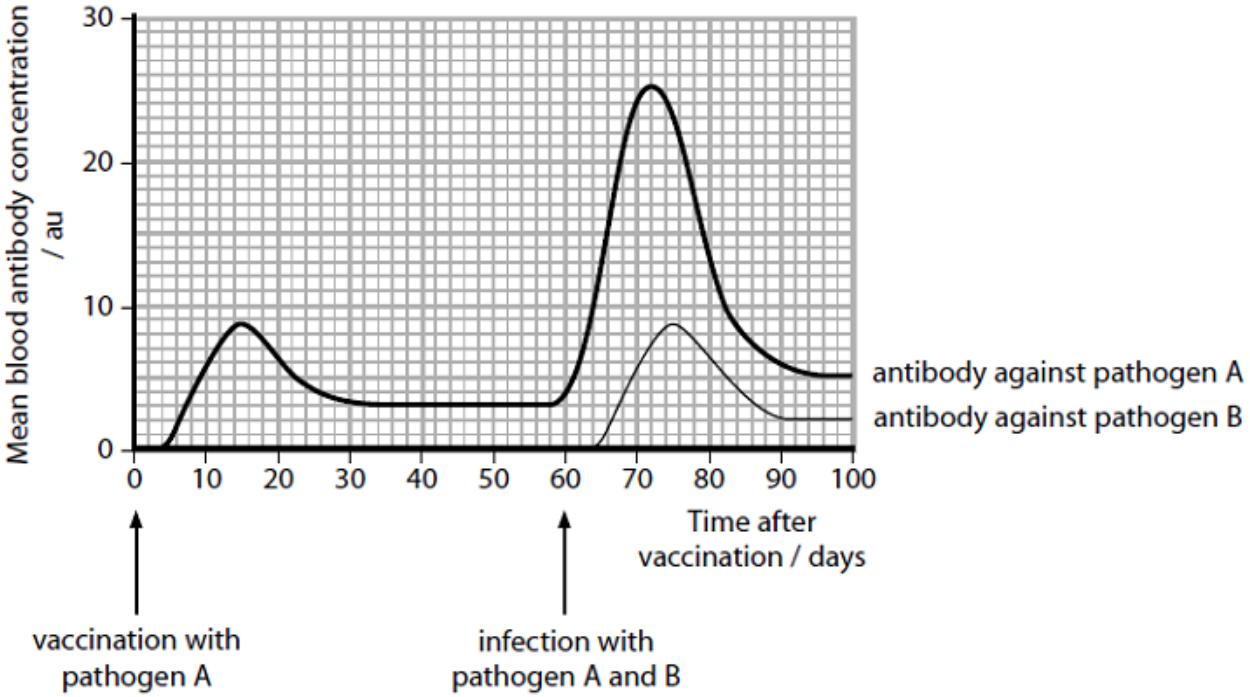
(Total for question = 11 marks)

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.

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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.

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

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

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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.

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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).

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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.

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(Total for question = 3 marks)

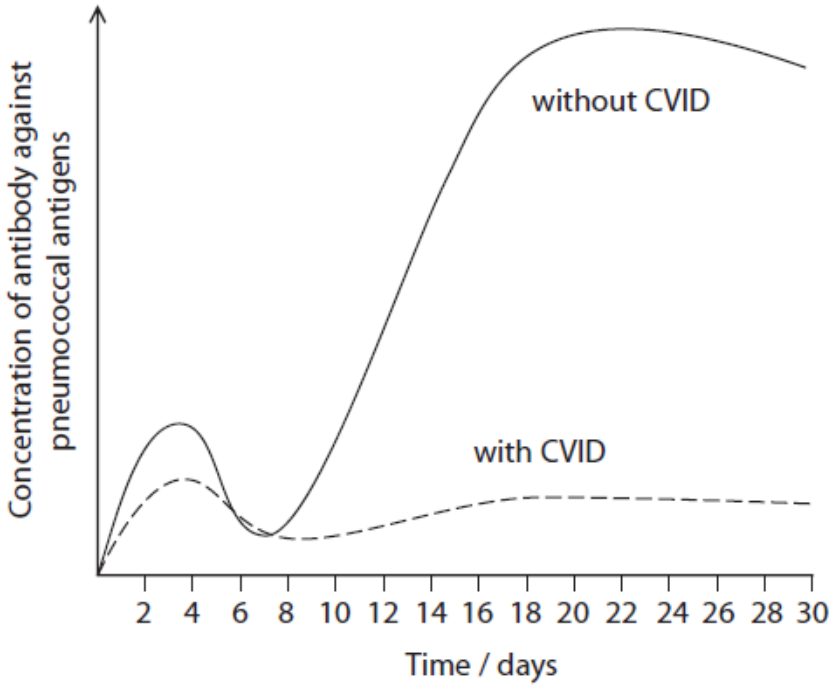
Q19.

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)

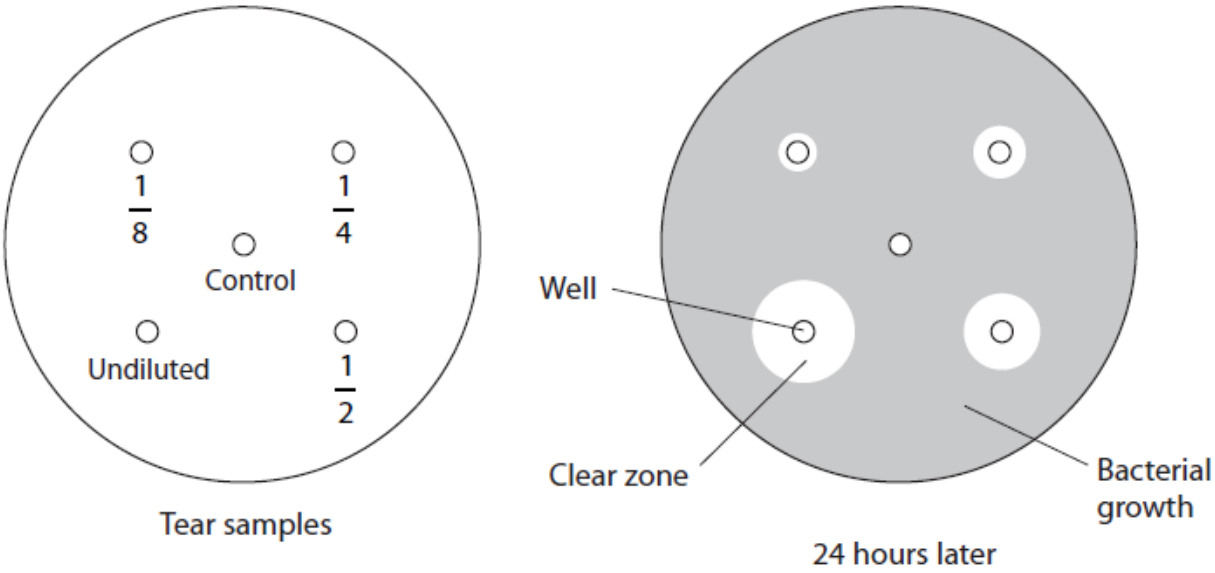
Q20.

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)

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(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.

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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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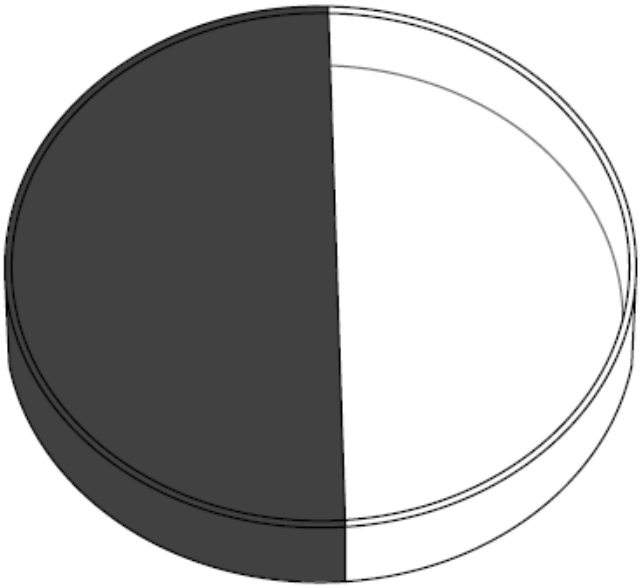
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(Total for question = 11 marks)

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

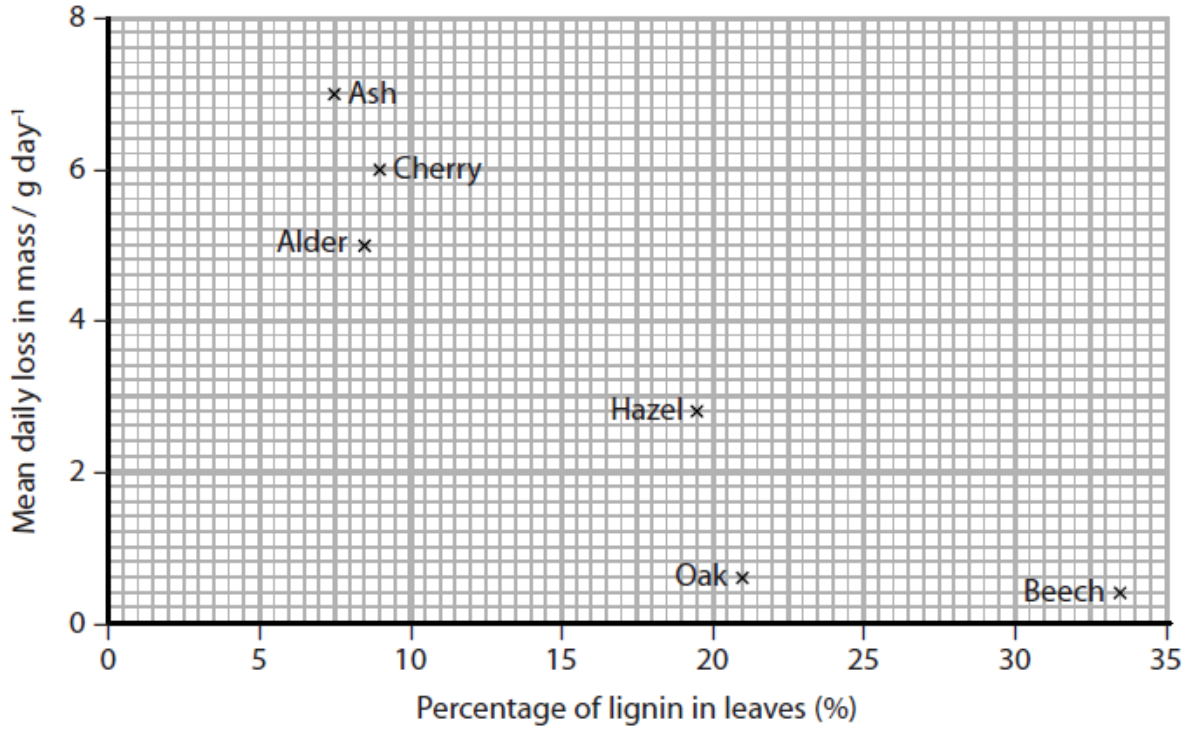
☒ **D** bacteria, fungi and viruses

(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.

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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).

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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)

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.

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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.

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(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.

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

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

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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.

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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.

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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.

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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?

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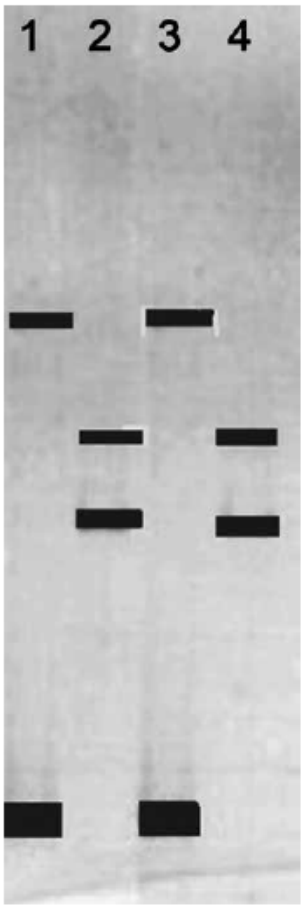
☒ **A** large fragments move further than small fragments towards the anode

☒ **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.

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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.

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

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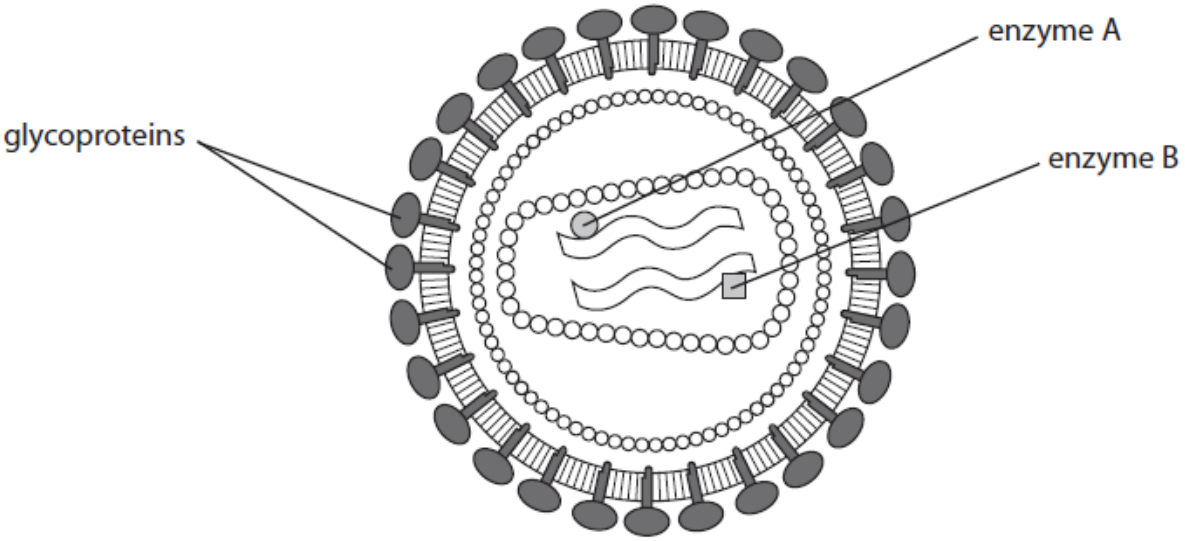
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(Total for question = 5 marks)

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.

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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.

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

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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.

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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.

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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.

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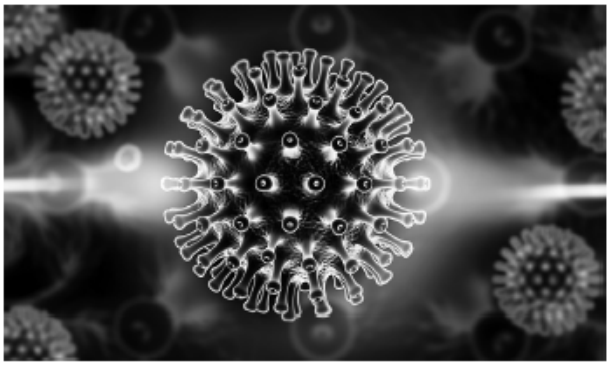
(Total for question = 11 marks)

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

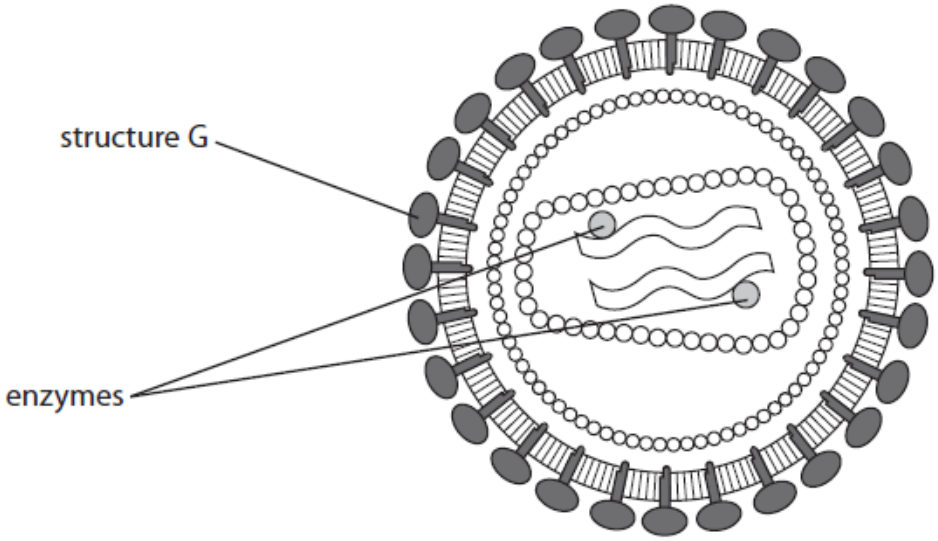
☒ **D** RNA and reverse transcriptase

(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.

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

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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).

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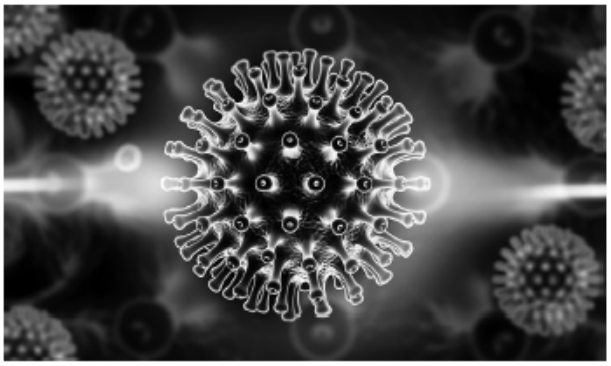
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(Total for question = 4 marks)

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.

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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

(3)

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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)

..... %

(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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(Total for question = 6 marks)

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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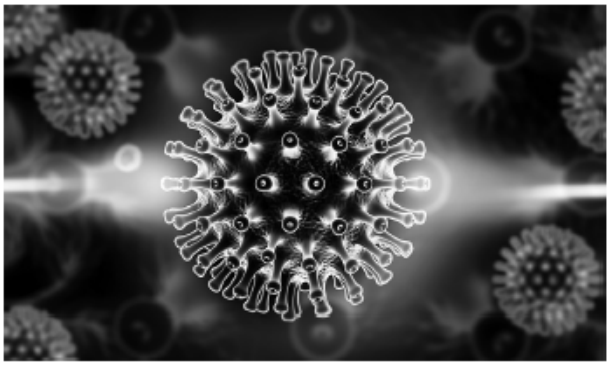
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(Total for question = 4 marks)

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.

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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)

Q1.

DNA synthesis in bacterial cell cultures has been investigated.

Describe how DNA is organised in a bacterial cell.

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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.

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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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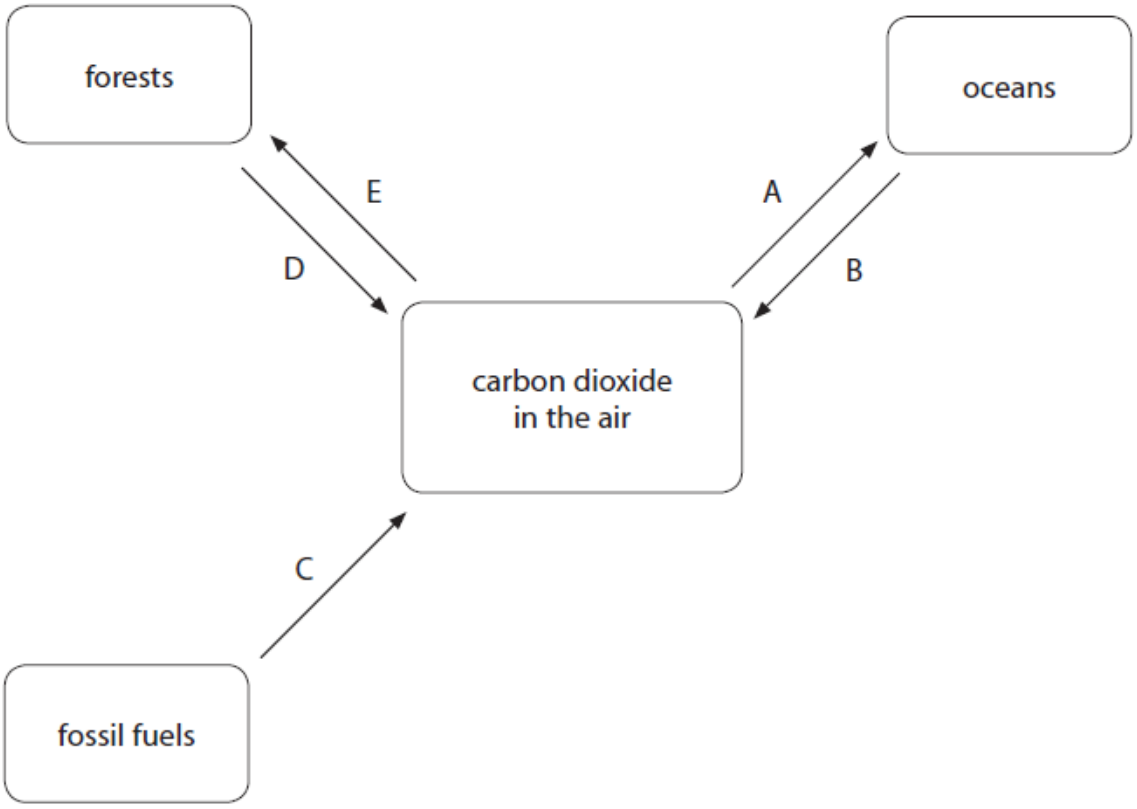
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(Total for question = 3 marks)

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.

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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.

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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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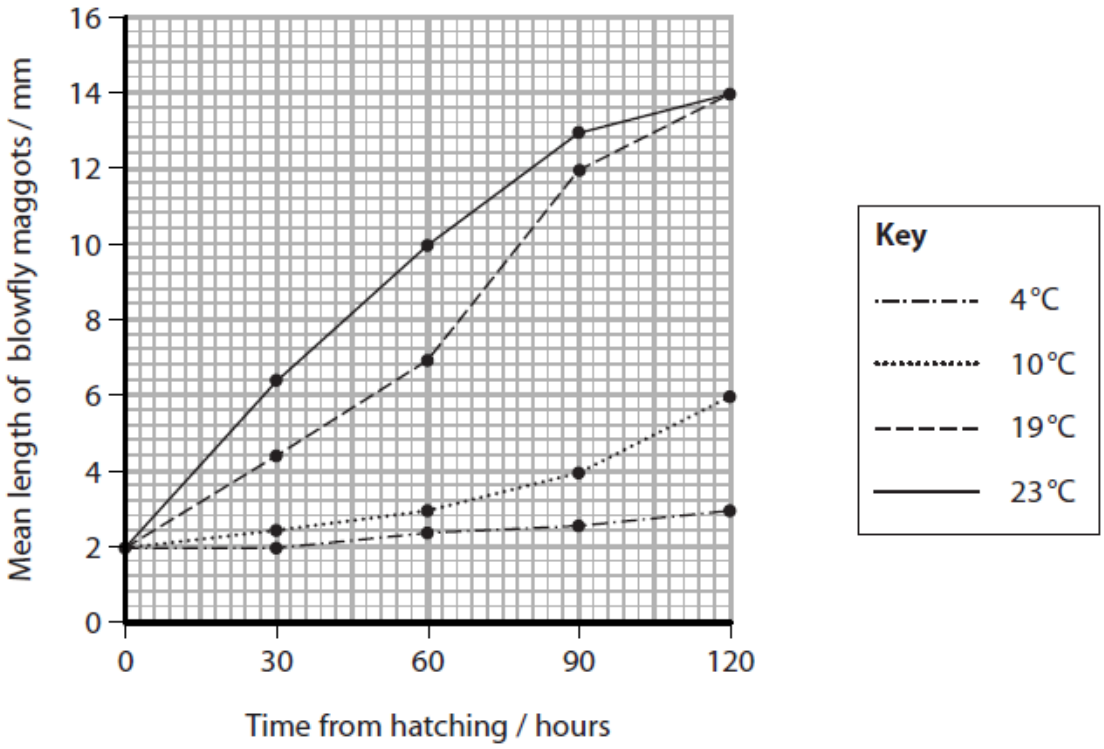
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Q10.

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

© hairymuseummatt/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

(Total for question = 1 mark)

Q12.

Grey tree frogs are found in the USA.

The photograph below shows a grey tree frog.



Magnification ×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.

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(ii) Suggest how these DNA profiles were compared.

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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.

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(Total for question = 11 marks)

Q13.

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

The photograph below shows an Atlantic tomcod.



Magnification ×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.

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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.

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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.

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(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

© hairymuseummatt/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.

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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.

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(Total for question = 9 marks)

Q16.

DNA synthesis in bacterial cell cultures has been investigated.

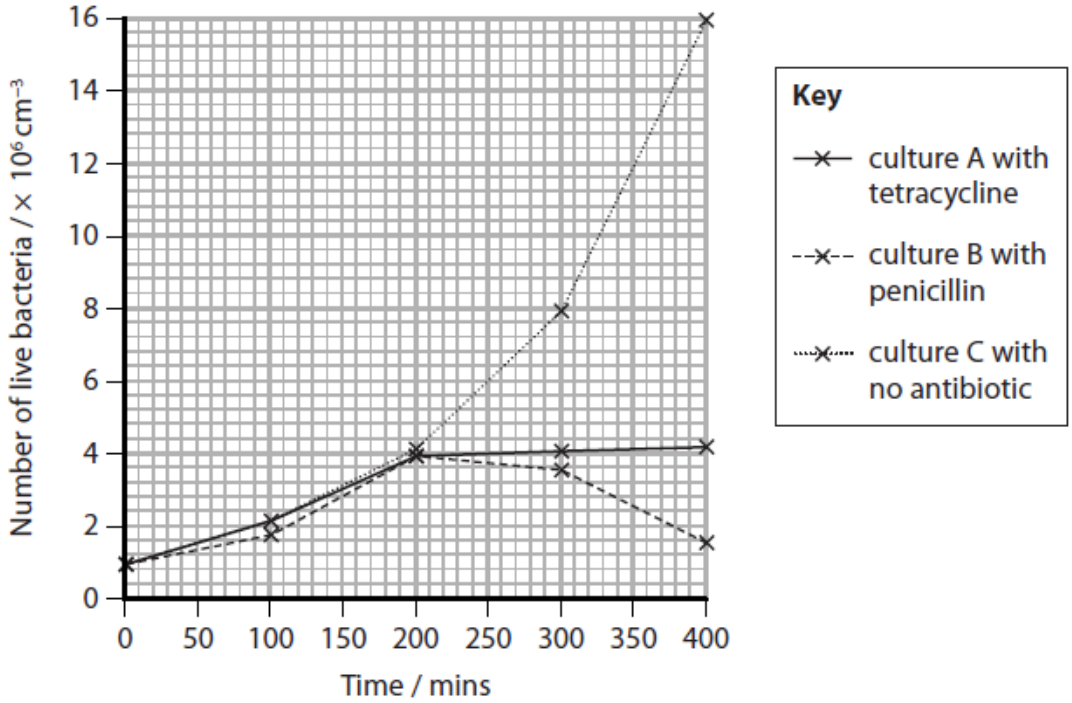
Antibiotics can be used to control bacterial infections.

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

© hairymuseummatt/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.

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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).

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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.

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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.

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(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.

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(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.

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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.

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(Total for question = 3 marks)

Q25.

Phagocytosis is a non-specific response of the body to infection.

Explain the meaning of each of the following terms.

(i) Phagocytosis

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(ii) Non-specific response

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(iii) Infection

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