WJEC EDUQAS A-LEVEL BIOLOGY · COMPONENT 3

BIOLOGY



EXAM QUESTION PACK

OPTION A: IMMUNOLOGY AND DISEASE

SCORE	PERCENTAGE
/147	%

STEMUP

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1. Zika is an RNA virus, which can be spread by the *Aedes* mosquito. Most people infected with the Zika virus experience no or very mild symptoms. A recent outbreak in South America was accompanied by an increase in the number of babies being born with microcephaly (a significantly smaller head and abnormal brain development). The incubation period for the Zika virus is estimated to range between 3 and 12 days. The symptoms, if experienced, are similar to other mosquito-borne diseases such as malaria and include: fever, rash, muscular pain, joint pain and headaches.

In 2016, concern was expressed by athletes travelling to the Olympics in Brazil regarding possible infection with Zika. The World Health Organisation concluded that the risk of transmission was relatively low. The advice given to anyone travelling to the Olympics was:

- use insect repellent and wear loose clothing that covers the body
- keep windows closed at night and sleep under a mosquito net
- avoid areas with poor sanitation and stagnant water.

(a) (i) State the term given to the *Aedes* mosquito in the lifecycle of the Zika virus. [1]

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(ii) Explain how the preventative methods described above would help reduce the chance of infection with Zika. [2]

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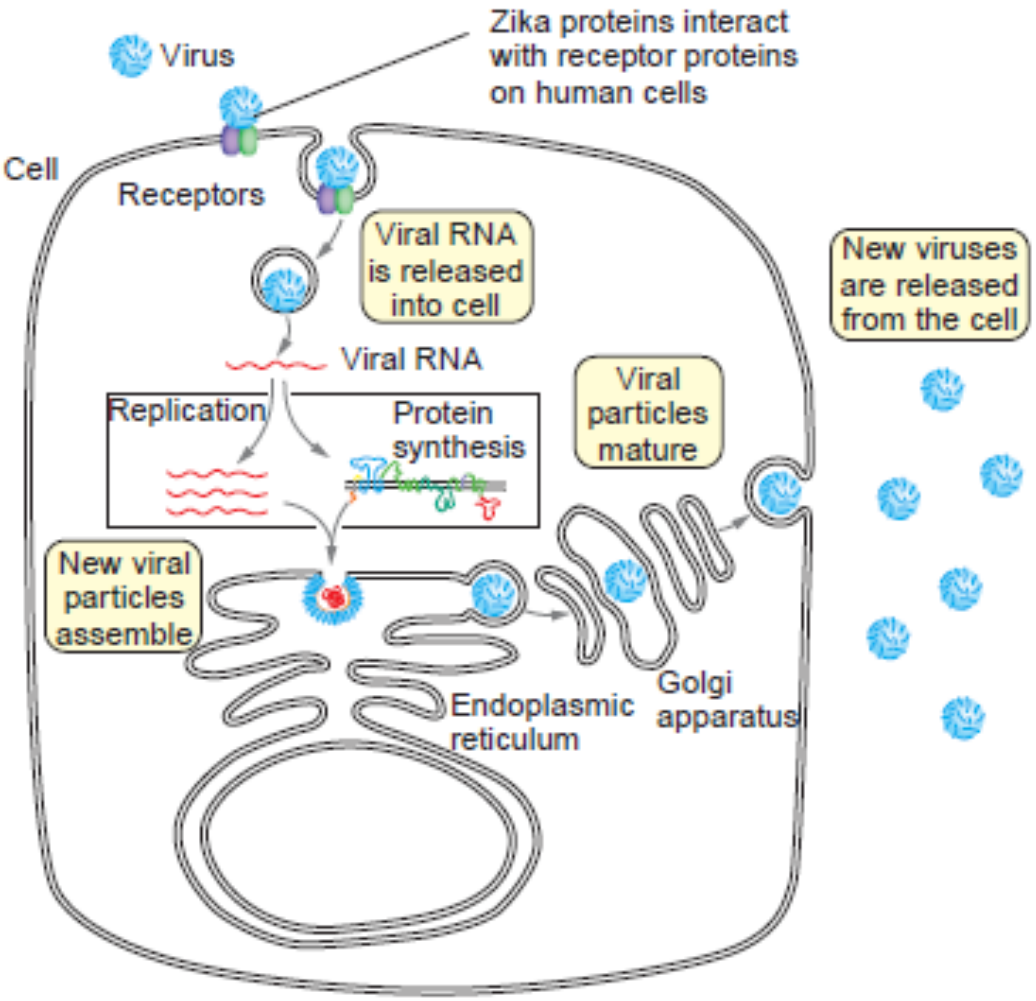
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(b) The diagram below describes how the Zika virus replicates inside a human cell.



(i) With reference to the diagram, suggest why viruses are difficult to treat with drugs and state the challenges faced when attempting to develop a vaccine against Zika. [3]

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(ii) State two features of a successful vaccine. [1]

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(c) Urgent research is being carried out to provide protection against Zika to pregnant women, as quickly as possible as well as providing a long-term prevention strategy.

Two research projects currently in progress are:

1. The use of an injection containing anti-Zika antibodies for use in pregnant women. This has had some success in animal trials with mice.
2. The development of a vaccine to confer immunity against the virus.

Evaluate the relative advantages and disadvantages of these strategies in the prevention of Zika cases. State which one would be more effective in the long term and explain your reasoning. [5]

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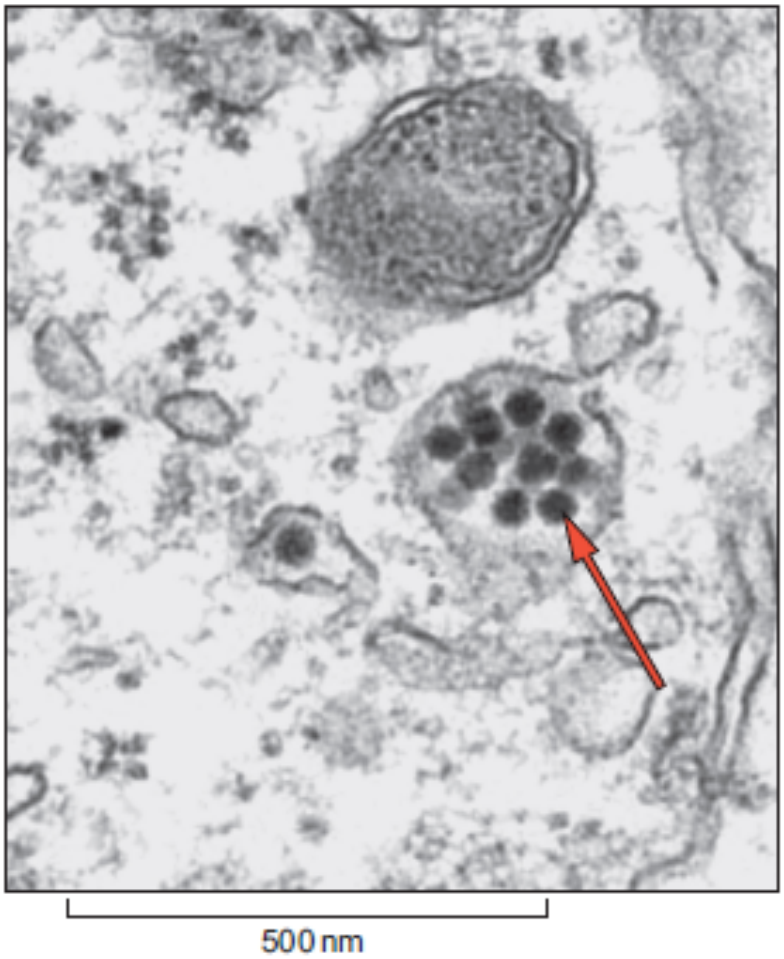
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(d) The image below is an electron micrograph showing part of a human cell infected with Zika. Virus particles are in membranous vesicles, the **arrow on the micrograph** below indicates **one virus particle**.



Use the scale bar to calculate the diameter of the labelled Zika virus particle. [2]

Diameter = ... nm

(e) Methicillin works in a similar way to penicillin and is said to be bactericidal. It is no longer produced for medical use because of the rapid increase in bacterial resistance to it. Methicillin resistant *Staphylococcus aureus* (MRSA) is endemic in the general human population. Infections caused by MRSA are common in hospital patients.

(i) State what is meant by the term *endemic* and suggest why MRSA is not a major cause for concern amongst the general population. [2]

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(ii) Erythromycin can be bactericidal or bacteriostatic depending on the dose. It binds to the large ribosomal subunit in bacterial cells. Suggest how erythromycin may work to treat bacterial infection and why it does not affect the patient's cell metabolism. [2]

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(f) Antibiotic resistance is a global crisis and measures are needed to control the use of antibiotics as well as developing new antibiotics. Clinical trials need to be done on any new antibiotic. A trial was carried out to test the safety of a new antibiotic using 20 healthy male volunteers from the same ethnic background. Evaluate the validity of this trial in terms of its use in the whole population. [2]

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2. *(a)* In 2010, an earthquake hit the country of Haiti in the Caribbean, causing devastation and severe damage to the water supplies and sewage treatment facilities. United Nations peace keepers from Nepal came to the country to help with the disaster. An epidemic of cholera broke out 10 months after the earthquake affecting hundreds of thousands of people. Cholera was not endemic to Haiti. Cholera is caused by the gram negative bacteria *Vibrio cholerae* and causes severe dehydration due to diarrhoea.



(i) Define the terms *endemic* and *epidemic*. [2]

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(ii) Explain how cholera spread in Haiti. [2]

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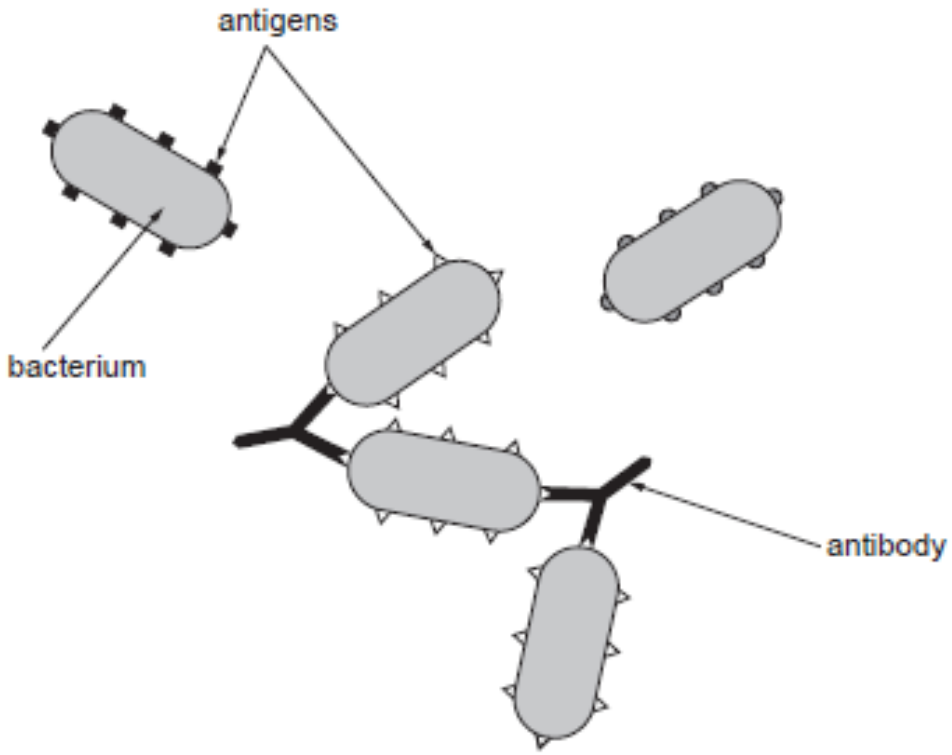
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(iii) Conclude what could have been the original source of the cholera epidemic, explain your answer. [1]

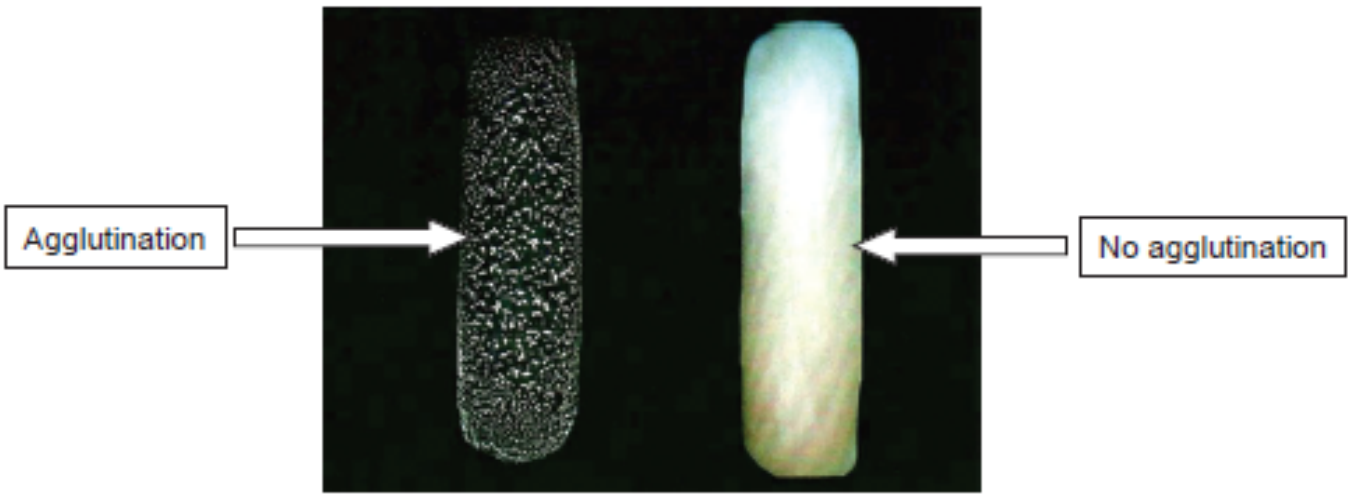
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(b) Cholera is caused by the production of cholera toxin by 2 strains of *V. cholerae*, O1 and O139. An agglutination test can be carried out to test for the presence of O antigens on the bacterial surface. Agglutination is when clumping takes place between antibodies and antigens. A different agglutination test can be carried out to test for each of the strains.



Samples were taken from patients for testing to confirm the strain of bacteria and determine the source of the outbreak.



(i) Explain why an agglutination test would be able to distinguish between the two strains of cholera bacteria. [3]

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(ii) How would the scientists be able to confirm the source of the outbreak? [2]

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(iii) Suggest why some patients with severe symptoms are given antibiotic tablets, but antibiotics alone are not a cure for the disease. [3]

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(iv) Treatment for severe dehydration caused by Cholera is by intravenous rehydration. Patients are given 200 cm^3 of fluid per kg of body mass in a 24 hour period. Calculate the volume of liquid per hour to be given to a patient weighing 70 kg. [2]

Volume of liquid per hour = ... cm^3

(c) Oral cholera vaccines can be used to prevent the disease if there is a risk of an epidemic. Two doses of the vaccine are required. Shancol is a vaccine which has been used successfully in areas of endemic cholera but was not used during the Haiti epidemic as it had not then been authorised for use by the United Nations/World Health Organisation (UN/WHO).

(i) Explain why the oral vaccine must be administered in two doses. [2]

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(ii) State **one** reason why a higher concentration of the vaccine must be used when given orally. [1]

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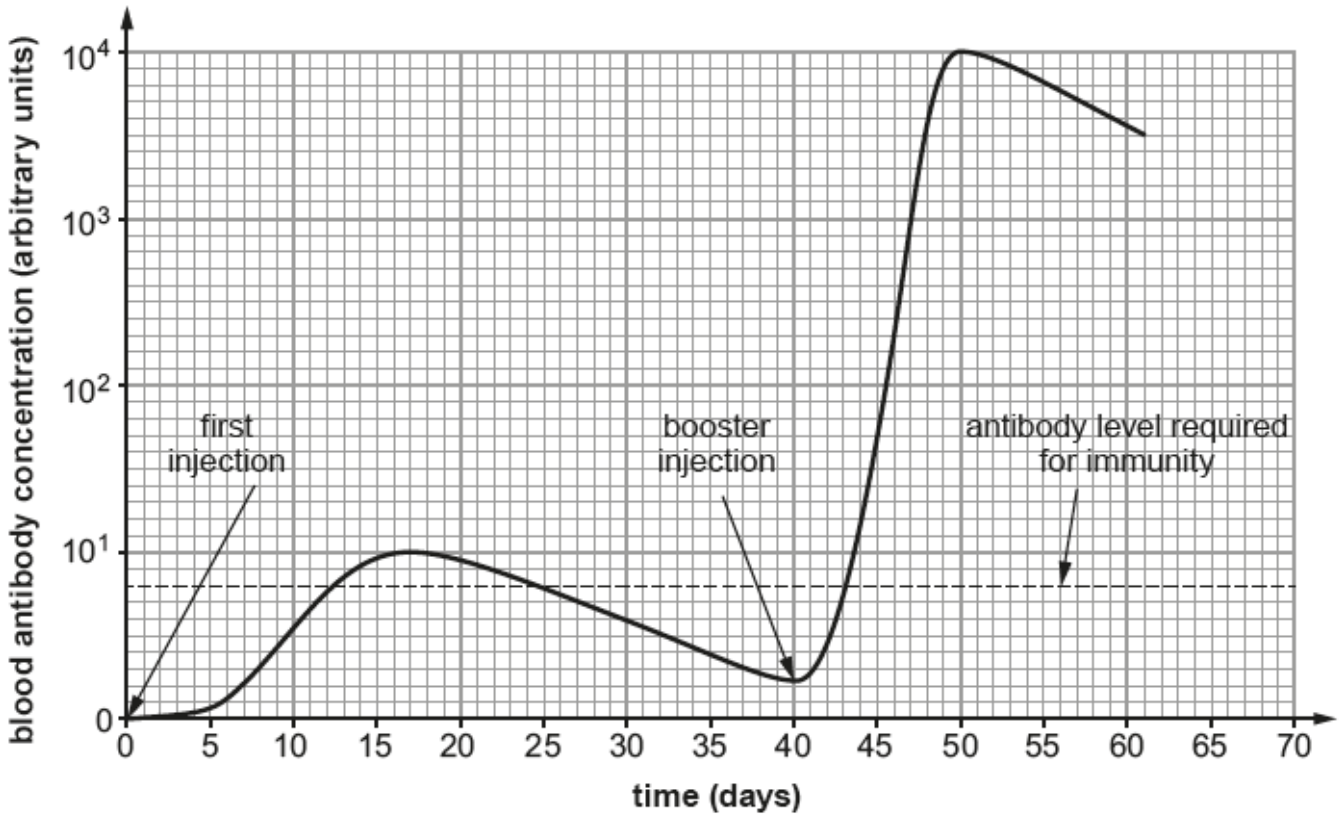
(iii) What considerations would need to be made by the UN/WHO before allowing the use of a vaccine in Haiti? [2]

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3. The graph shows how blood antibody concentration against Rubella changed in a 12 month old child following an injection with Rubella antigen at day 0 followed by a booster injection at day 40.



(a) (i) State the time taken to produce the antibody level required for immunity following the first injection with Rubella antigen. [1]

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(ii) Explain why the time taken to produce the antibody level required for immunity was much shorter following the booster injection. [2]

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(b) The child, who had not been exposed to measles previously, was given a separate immunisation against the measles virus at Day 40 - the same day that she received the booster injection against *Rubella*.

(i) On the graph opposite, draw a line to show how the blood antibody concentration against **measles** changes from the immunisation at **day 40** to **day 60**.

[3]

(ii) Explain why the blood antibody concentration against measles would change in this way.

[2]

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4. Complete the following sentences giving the correct name.

(a) A disease which is always present at low levels in an area is referred to as

[1]

. . . . . .

(b) A person who shows no symptoms when infected by a disease but can still pass the disease on to another individual, is referred to as a

[1]

. . . . . .

(c) Organisms which carry pathogens from one individual to another are called

[1]

. . . . . .

(d) Antibiotics that prevent bacterial growth are referred to as

[1]

. . . . . .

(e) The term used to describe a disease which may be passed or transmitted from one individual to another is

[1]

. . . . . .

5. Cholera is an infection of the gut lining caused by the bacterium *Vibrio cholerae*. The bacterium releases toxins that cause watery diarrhoea leading to severe dehydration and frequently death.

Transmission occurs primarily by drinking water or eating food that has been contaminated by the faeces of an infected person. In the ten months following the earthquake in Haiti in 2010, over 60,000 cases of cholera were reported, concluding in 1400 deaths.

(a) Describe how the spread of cholera could have been **prevented** following the earthquake.

[2]

(b) The diagram below shows part of the cell wall taken from Vibrio cholerae.



(i) Name **two** components found in the outer layer.

[2]

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(ii) Name the component found in layer **X**.

[1]

(iii) What colour would you expect this bacterium to be following the gram stain test?

[1]

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(iv) Explain why penicillin is ineffective in treating cholera.

[3]

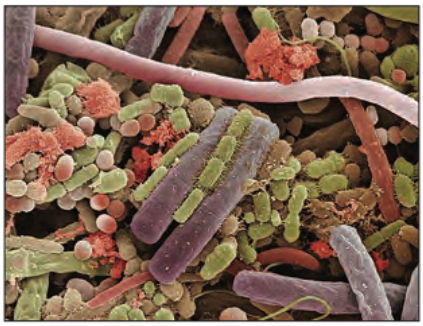
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6. *(a)* Although micro-organisms can cause disease in humans, scientists believe that up to 10^{16} symbiotic microbial cells live in or on the human body. Up to 90% of all diseases can be traced back in some way to the composition of this microbiome. Figure 8.1 shows bacteria on the surface of a human tongue.

Figure 8.1



An average adult has 10^{13} cells in the body. Suggest why it is often said that we are more microbe than human in terms of our genomes and describe how the micro-organisms living inside our bodies and on the skin surface help protect us from infectious disease.

[3]

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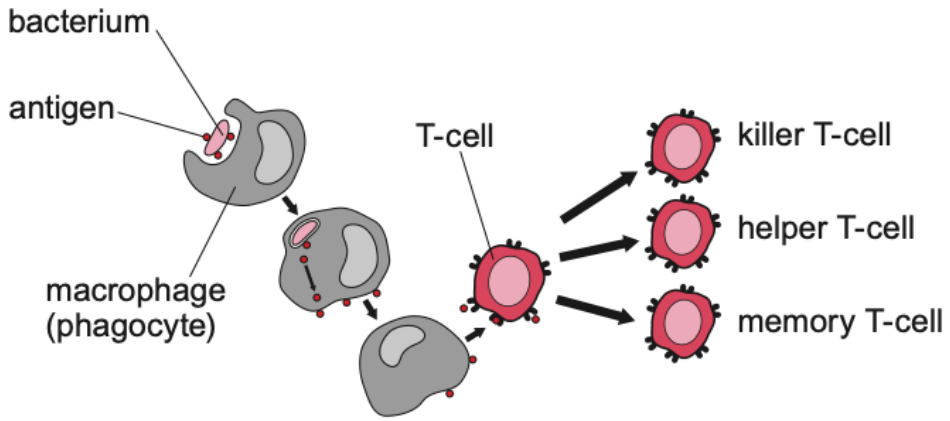
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(b) Figure 8.2 shows part of the T-cell immune response when the body is infected with a pathogenic bacterium, such as *Vibrio cholerae*.

Figure 8.2



(i) Explain the role of the macrophage in the T-cell response. [3]

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(ii) Describe the roles of each of the T-cell types shown in figure 8.2 as part of the immune response. [3]

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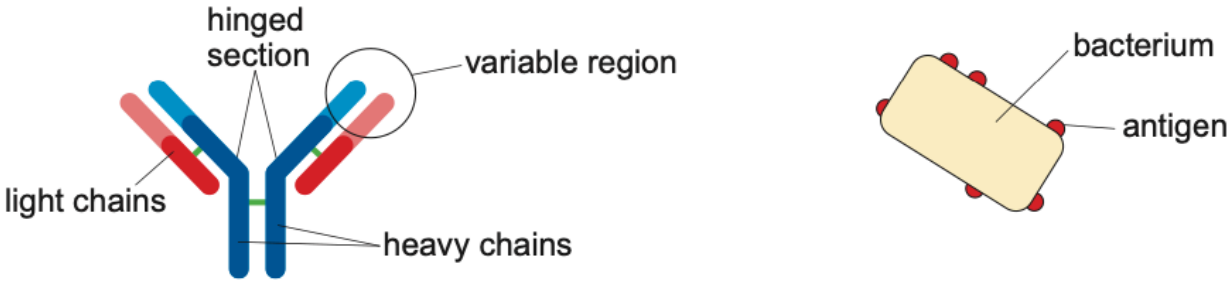
(c) B-cells are activated in a similar way but synthesise antibodies that are specific protein molecules that can bind to foreign antigens. These antibodies can be of different types, as shown in figure 8.3.

Figure 8.3



IgM is made up of five antibody molecules bonded together. A more detailed diagram of IgG is shown in figure 8.4 along with a bacterial cell, showing antigens on the surface.

Figure 8.4



(i) The hinged sections of the IgG molecule give it some structural flexibility. Suggest an advantage of this. [2]

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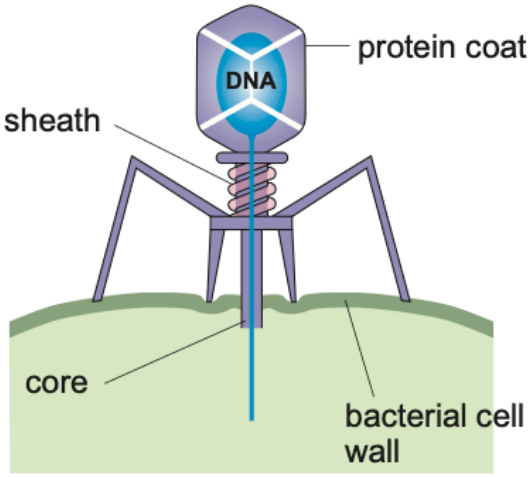
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(ii) Suggest an advantage of the IgM molecule over IgG [1]

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(d) Bacteriophages are viruses which infect bacteria specifically. When they infect bacteria, they result in cell lysis. Bacteriophages are harmless to humans. A typical bacteriophage is shown in figure 8.5.

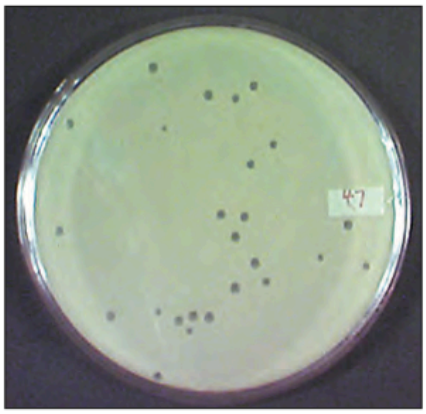
Figure 8.5



Bacteriophage therapy has been successful in trials against a range of bacterial infections, including chronic skin infections caused by bacteria such as MRSA. Their use in medicine to treat infectious disease in humans is called phage therapy.

Bacteriophages can be isolated from bacterial cultures and they can be grown on nutrient agar plates in a lawn of bacteria. Clear zones (plaques) appear on the plates as bacteria are lysed by the bacteriophages as shown in figure 8.6.
Each plaque is assumed to originate from a single bacteriophage.

Figure 8.6



The plate in figure 8.6 was prepared by mixing 0.02 cm^3 of a 10^{-5} dilution of bacteriophages with a bacterial culture and spreading it on an agar plate. This plate was incubated for 24 hours at 37 °C.

(i) On the plate shown in figure 8.6 there are 25 plaques. Calculate the number of bacteriophages per cm^3 in the original sample. [2]

Number of bacteriophages = ...

(ii) Describe **two** techniques that could have been used to maintain sterile conditions when inoculating the plates. [2]

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(iii) Explain why 37 °C was used as the incubation temperature. [1]

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(iv) Using the information provided and your own knowledge, suggest **two** disadvantages of antibiotic use that could be overcome by phage therapy. [2]

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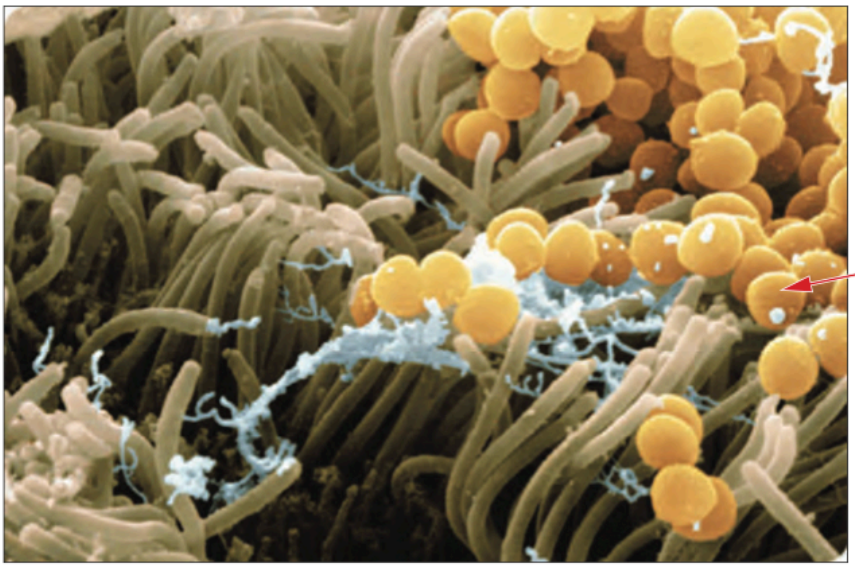
(v) Suggest an ethical issue that should be considered before widespread use of phage therapy in humans. [1]

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7. *Neisseria meningitidis* is an airborne pathogenic bacterium that can cause one type of meningitis.

The photomicrograph below of an airway's lining shows an example of the body's natural barriers to infection by pathogenic bacteria.



(a) With reference to the photograph, describe this first line of defence. [1]

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(b) *Pseudomonas aeruginosa* is a Gram-negative bacterium that can be easily spread by hands as a type of direct contact. *P. aeruginosa* infections can be treated with a bactericidal antibiotic called Colistin that binds to lipopolysaccharides and phospholipids in the outer cell layer of Gram-negative bacteria.

Using your knowledge of bacterial structure and antibiotics explain how penicillin acts and why it cannot be used to treat *P. aeruginosa*. [3]

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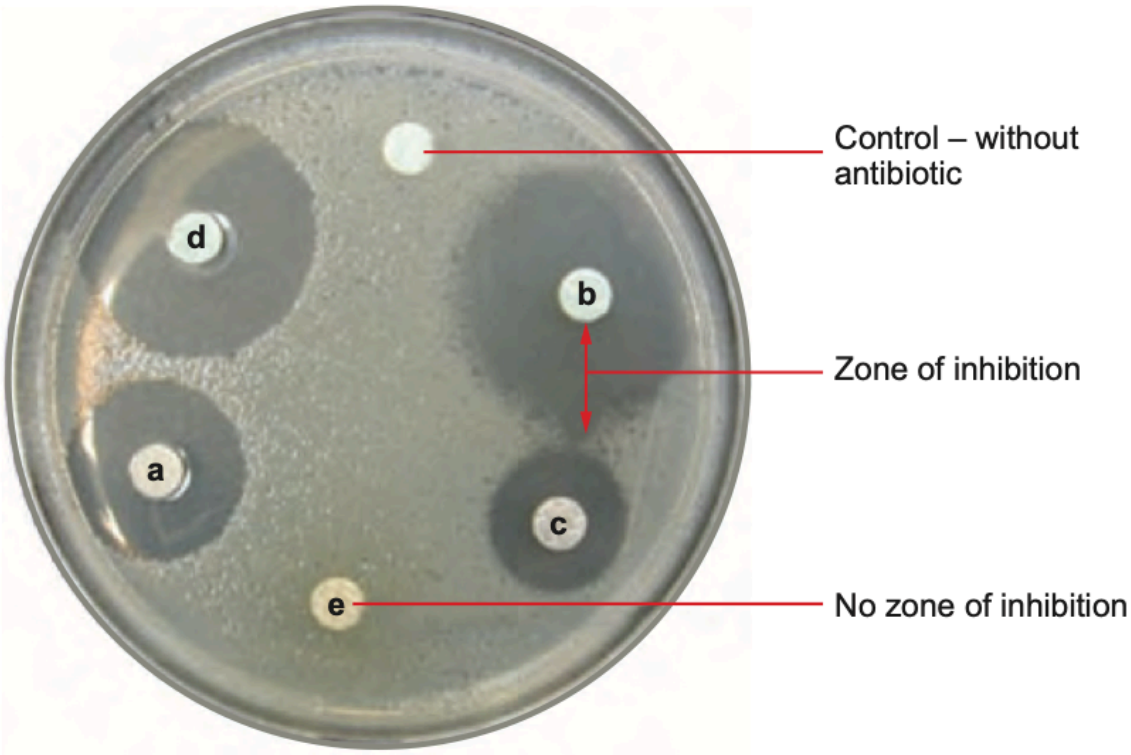
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Colistin is known as a "last resort" antibiotic, increasingly used to treat infections that resist every other antibiotic. However, in November 2015, bacteria were found resistant to this antibiotic. Microbiologists are constantly researching new antibiotic compounds.

The illustration below shows zones of inhibition around filter paper discs. The discs are all the same size and saturated with the same concentration of different antibiotic compounds and placed on bacteria growing on agar. The antibiotic will diffuse out of the filter paper. The radius of the zone of inhibition is a measure of the effectiveness of the antibiotic compound.



(c) Since this method depends on diffusion of the antibiotic, it is important to keep several factors constant.

(i) State **two** variables that should be controlled. [2]

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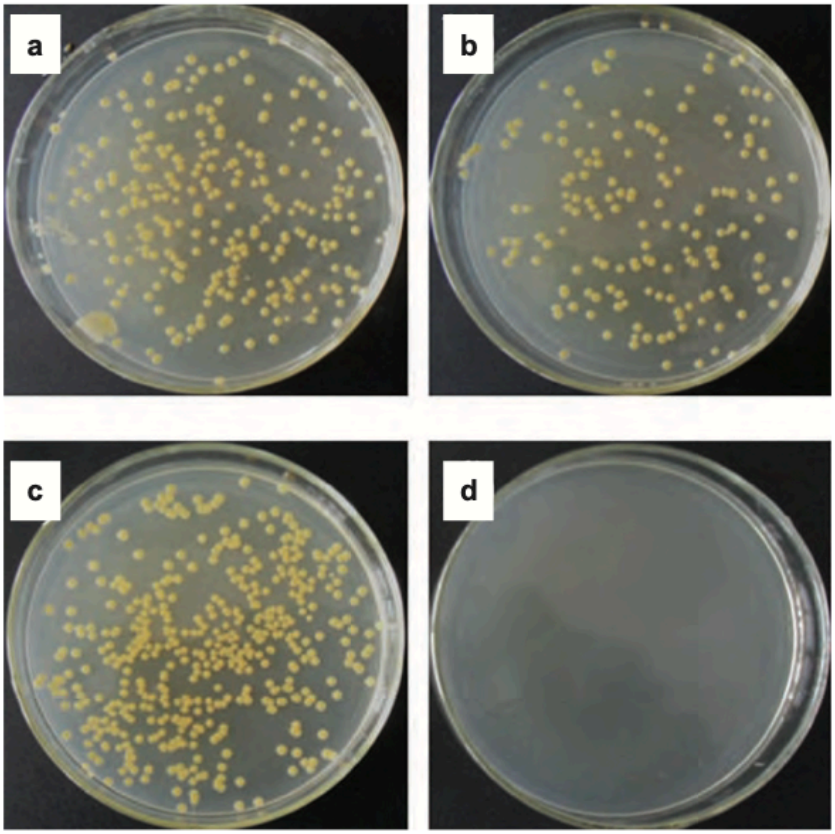
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(ii) Explain how you could identify which antibiotic worked the best. [1]

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(iii) A sample of bacteria was removed from each zone of inhibition generated by the working antibiotics. These bacteria were then re-plated without the antibiotics and cultured.
The images below show the results for antibiotics **a** to **d**.



Conclude the mode of action of each of these antibiotics. Explain how you reached this conclusion. [2]

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(d) Antibiotics have no effect on viruses. Chickenpox is a highly infectious airborne disease caused by the varicella-zoster virus. The virus spreads easily in the air when an infected person coughs or sneezes. Airborne viruses have antigens that can attach to the surface membrane of cells lining the trachea.

Explain why the varicella-zoster virus needs to enter the cells of the trachea and the effect this has on the cells. [2]

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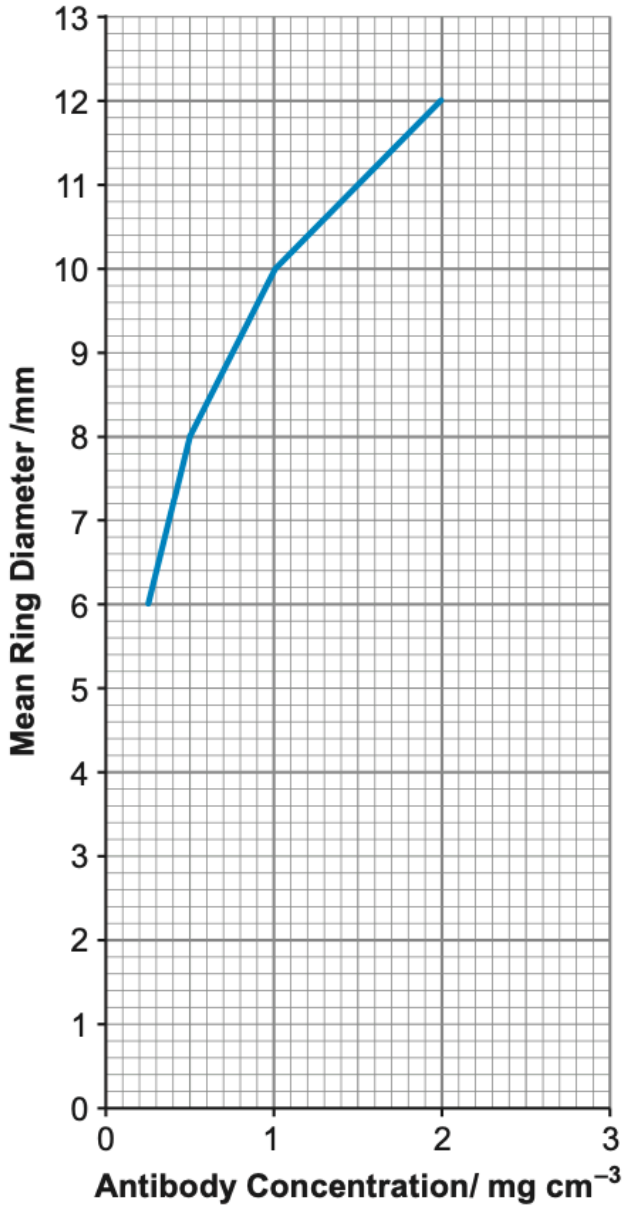
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(e) Radial Immuno Diffusion is a quantitative technique used to estimate antibody concentration. Agar plates are set up with a known concentration of antibody included in the agar. Pure antigens are added to the centre of each plate. The antigens diffuse through the agar and form antigen-antibody complexes which can be seen as a precipitation ring. The diameter of the ring is used to plot a calibration curve to estimate the concentration of antibodies in the blood samples as shown below.



(i) Use the graph to estimate the antibody concentration of the sample taken before vaccination and after. **Write your answers in the table below.** [1]

Sample	Ring diameter / mm	Antibody Concentration / mg cm^{-3}
Before Vaccination	7	
Following Vaccination	11	

(ii) Using your knowledge of the humoral response, explain the concentration of antibodies after the vaccination. [3]

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(iii) To assess the effectiveness of the vaccine the technique was repeated with several blood samples taken from a number of volunteers. A statistical test was used to assess the significance of the differences in the antibody levels before and after vaccination.
State the null hypothesis. [1]

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(iv) The test gave a value greater than the critical value at a probability of 0.05.
State whether you would accept or reject the null hypothesis and explain why. [1]

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(v) A protective antibody response to a vaccine requires at least a fourfold increase in antibody concentration. **Using the table opposite**, calculate the minimum antibody concentration that would be required to be protective. [1]

increase in antibody concentration = ...

(vi) State whether the results shown opposite indicate a successful vaccination and explain why annual vaccination programmes against influenza are not always effective. [2]

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8. Lyme disease, or Lyme borreliosis, is caused by the bacteria *Borrelia burgdorferi* and is endemic in some areas. There are a number of strains of this bacterium. The bacteria are transmitted to humans through the bite of an infected tick. Reported cases in England and Wales rose from 268 in 2001 to 959 in 2011, with an increase in the number of cases in Snowdonia National Park.

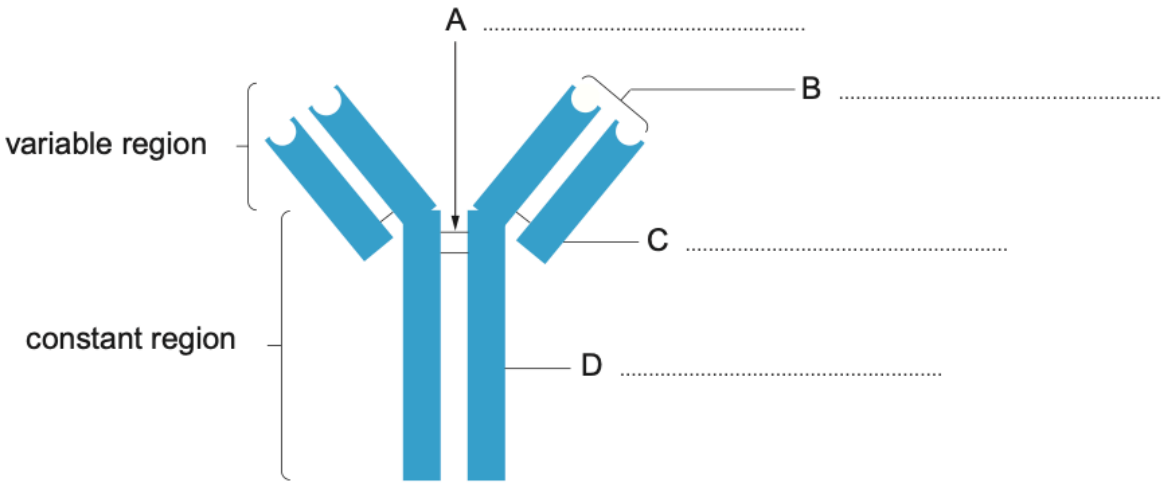
Ticks are tiny, spider-like creatures found in woodland and heath areas. They feed on the blood of birds and mammals, including humans. Ticks that carry the bacteria responsible for Lyme disease are found throughout the UK and in other parts of Europe and North America.

(a) State what is meant by the term *endemic*. [1]

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The immune system of an infected person will react by producing specific antibodies to the bacterial antigens.

(b) (i) Label the diagram below to identify the regions of the antibody. [3]



(ii) Define the term *antigen*, and explain the meaning of an antigen-antibody complex. [2]

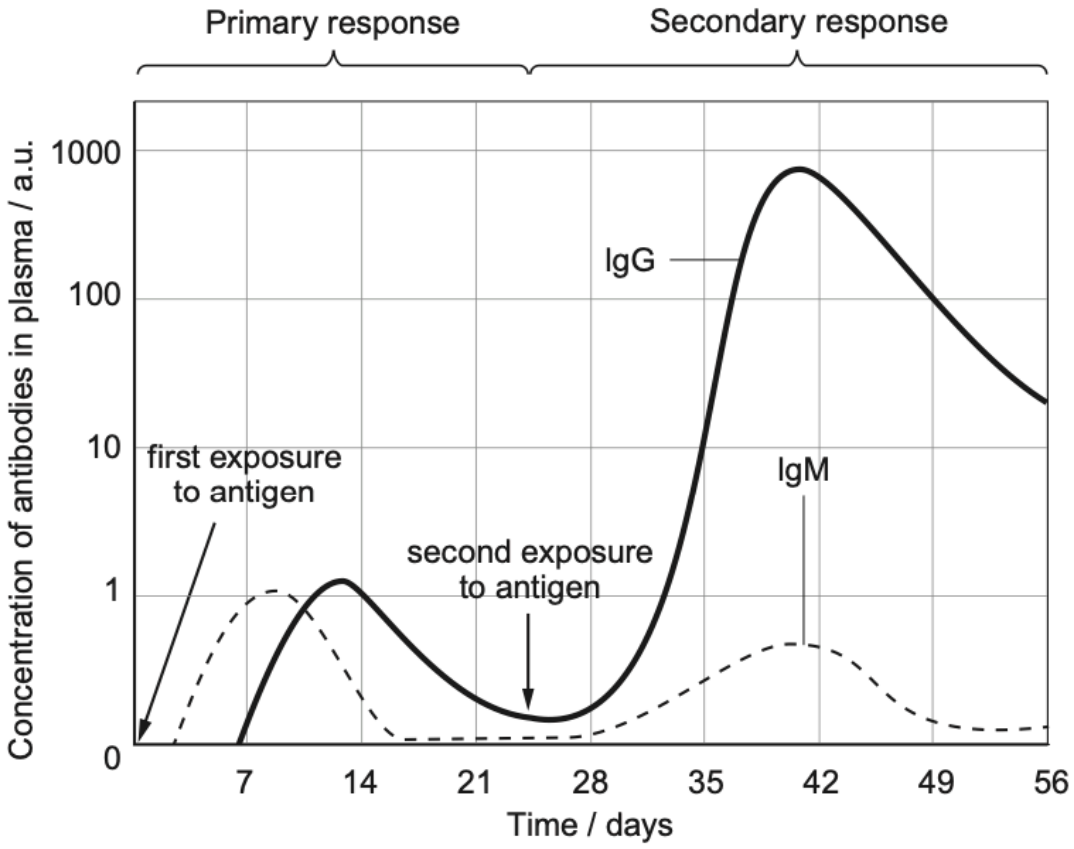
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(c) The body's response to infection shows both a primary response and a secondary response to the foreign antigens. Both responses can be identified by measuring the levels of two antibodies found in the blood, IgM and IgG.
IgM is produced mainly by B-cells on initial exposure; IgG antibodies are produced in higher levels during the secondary response.



(i) Explain why the level of IgG is higher after the second exposure to the antigen than the first exposure. [1]

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(ii) Lyme disease can persist in patients for many years and the IgM levels remain high. Suggest possible reasons why. [2]

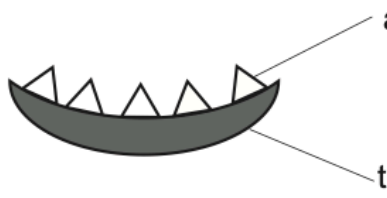
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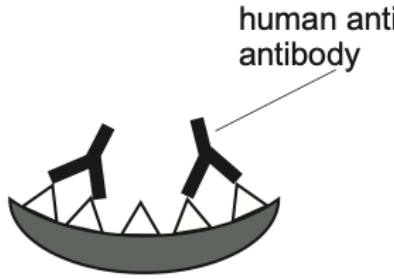
(d) The symptoms of Lyme disease include fever, chills, fatigue, headaches and muscle aches. As a consequence, patients with Lyme disease are often misdiagnosed.

An ELISA (enzyme-linked immunosorbent assay) can be carried out to diagnose Lyme disease using a blood sample from the patient around **two weeks** after infection. It is based on detecting the antibodies made in response to being exposed to *B.burgdorferi*.

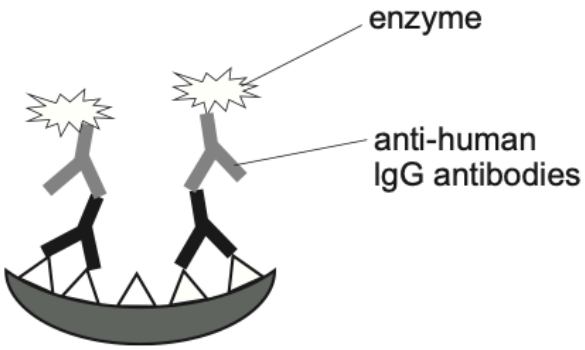
The results of the assay show the concentration of IgG antibodies in the patient's blood. The steps involved in the ELISA are shown below.



Specific antigen from *B.burgdorferi* attached to the surface of the test well.



Patient's blood plasma added to the well. Human antibodies bind to the *B.burgdorferi* antigen.



Enzymes attached to anti-human IgG antibodies cause a colour change if an antigen-antibody complex forms. Greater colour intensity indicates a higher IgG concentration.

(i) Using the graph, explain why carrying out an ELISA would not detect the IgG antibodies in the days immediately after the tick bite. [2]

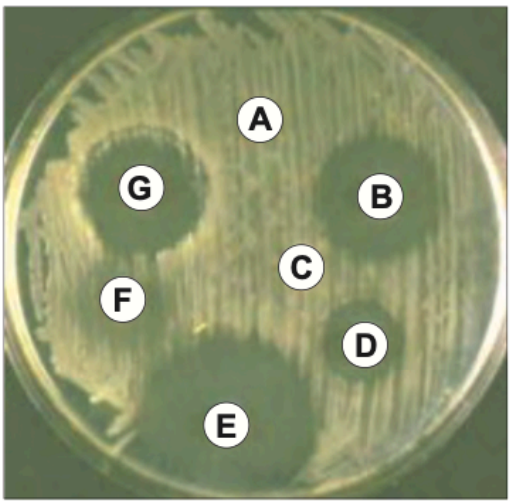
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(ii) The ELISA can produce false negative results for Lyme disease. In a false negative result there is no colour change, even if the patient is infected with the bacteria.

Suggest why, even if there are anti-*B.burgdorferi* antibodies in the patient's plasma, the enzyme may not cause a colour change. [5]

(e) *B.burgdorferi* is a Gram-negative bacterium and can be treated using a bacteriostatic antibiotic which stops protein synthesis.
The image below is of an agar plate showing the results of testing various antibiotics on *B.burgdorferi*.



(i) State the temperature at which the culture should be incubated.
Explain your answer. [1]

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(ii) The most effective antibiotic was found to be E. The diameter of the zone of inhibition was 22 mm. Calculate the area of the zone of inhibition caused by E to a suitable level of precision. [2]

Formula for the area of a circle: πr^2

$\pi = 3.14$

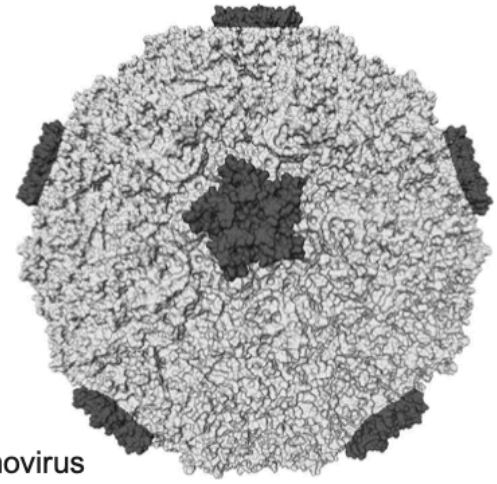
answer = ...

(iii) With reference to the image, suggest what assumption is being made when making this calculation. [1]

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9. The common cold is caused by a rhinovirus which infects the cells of the nasal epithelium.



Rhinovirus

Symptoms of this infection include a runny nose, sneezing, cough and sore throat. The nasal epithelium contains ciliated mucous membranes which usually act as a natural barrier to infection by trapping microbes entering in inhaled air.

(a) (i) State **three other** natural barriers to infection in the body. [1]

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(ii) Explain why the body is sometimes described as a host to other living organisms. [1]

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(iii) Rhinovirus uses the metabolic pathways of a host cell to produce many copies of the virus. Explain how infection with rhinovirus could cause cell death. [1]

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(iv) In cells infected with rhinovirus, the cell-mediated immune response involves the activation of B and T lymphocytes, and phagocytes.
Explain how phagocytes and T lymphocytes bring about the cell-mediated response against rhinovirus. [3]

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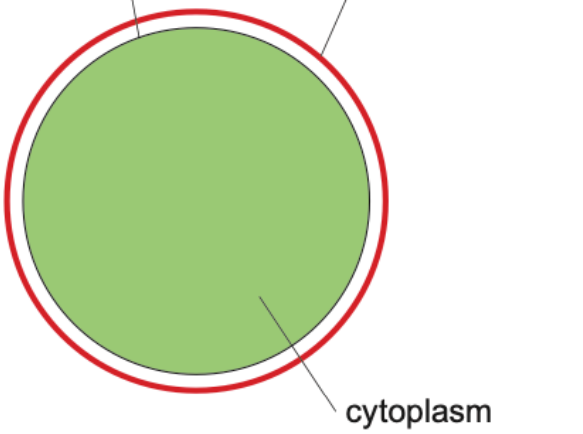
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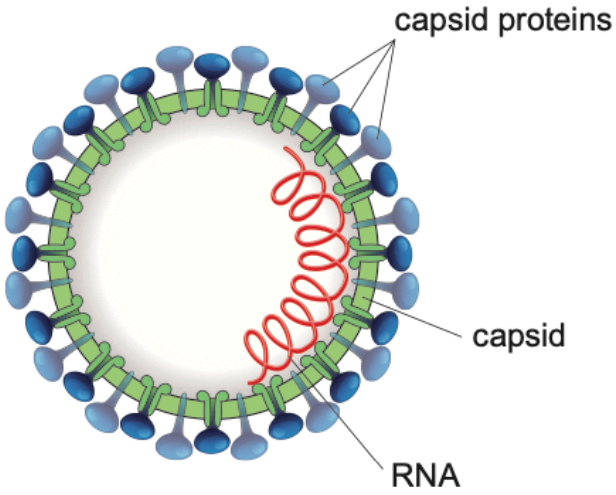
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(b) Symptoms of a cold can also be caused by other viruses and bacterial infections. *Streptococcus pyogenes* is a species of Gram-positive bacteria which produces similar symptoms. These symptoms can be treated with antibiotics. The diagrams below show simplified structures of a coccus bacterium (such as *S. pyogenes*) and a virus (such as rhinovirus).

S. pyogenes



Rhinovirus



(i) With reference to the diagram, explain why antibiotics can be used to treat colds caused by *S. pyogenes* but not those caused by rhinovirus. [3]

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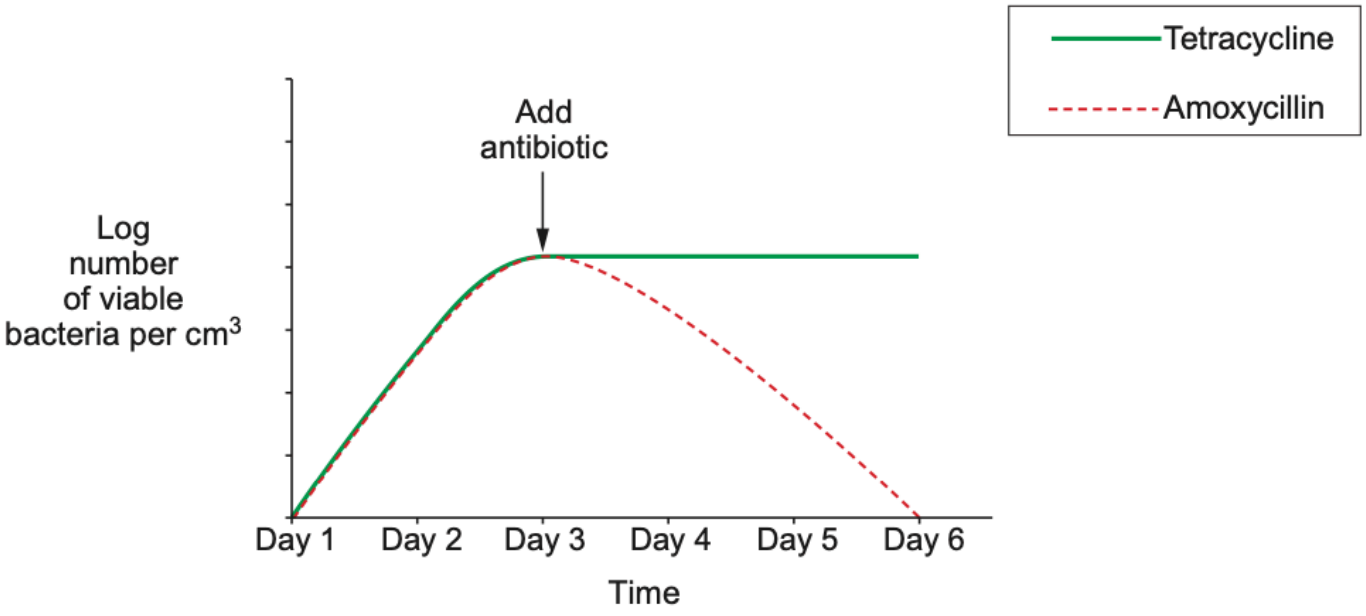
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(ii) Patients infected with *S. pyogenes* can be treated with the antibiotic amoxycillin which has a similar mode of action to penicillin. The recommended dosage is at 25 mg kg^{-1} twice a day for 10 days.
Calculate the total dosage over the 10 days for a child weighing 14.5 kg. [2]

Total dosage = ... mg

Scientists studied the effect of tetracycline and amoxycillin on *S. pyogenes*.

The same number of bacteria were inoculated into the same type of nutrient medium and cultured for 6 days at 35 °C in aerobic conditions. Amoxycillin was added to one culture and tetracycline was added to the other at day 3. The graph below shows how the number of viable bacteria change during the course of the experiment.



(iii) Using the graph, identify the mode of action of these two antibiotics and explain how you reached this conclusion. [2]

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(iv) State **two** factors that would need to be controlled to increase confidence in the results. [2]

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(v) Explain why *S. pyogenes* was cultured at 35 °C. [1]

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(c) Vaccination programmes for the common cold caused by rhinovirus have so far proved unsuccessful.

(i) Using your own knowledge of immunisation, suggest and explain why it is unlikely that a vaccine for the common cold will ever be developed. [3]

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(ii) The flu virus causes many similar symptoms to the common cold.
There is a vaccine against the flu virus which can provide protection. It is offered to certain 'at-risk' groups. These immunisations are not compulsory.

Suggest why it would be considered unethical to make the flu vaccine compulsory for all. [1]

.....

10. The bacterium, *Vibrio cholerae* is the causative agent of cholera. It produces a toxin which causes water and ions, such as sodium, chloride and potassium to be released from the blood into the intestine. This can result in death within 24 hours.

A new strain of the bacterium arose in the Far East in the 1960s and gradually replaced existing strains throughout much of the world but not in Western Europe.

This new strain is much more vigorous than the strain it replaced and the bacteria can continue to appear in faeces up to three months after a patient has recovered. In addition, it can survive in water for up to fourteen days. Cholera may be spread directly or indirectly and humans are the only reservoir of infection.

(a) Identify the **type** of bacterium to which *Vibrio cholerae* belongs. [1]

.....

(b) Describe how cholera may be transmitted. [1]

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.....

(c) Use the information in the passage to suggest how the toxin can lead to the death of a cholera patient. [3]

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(d) Suggest **two** reasons why the new strain of cholera has not become established in Western Europe. [2]

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(e) The antibiotic tetracycline is sometimes given to cholera patients.

(i) Describe **one** way in which the antibiotic can affect the *Vibrio cholerae*. [1]

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(ii) Explain why tetracycline is not routinely used to treat all cases of cholera. [2]

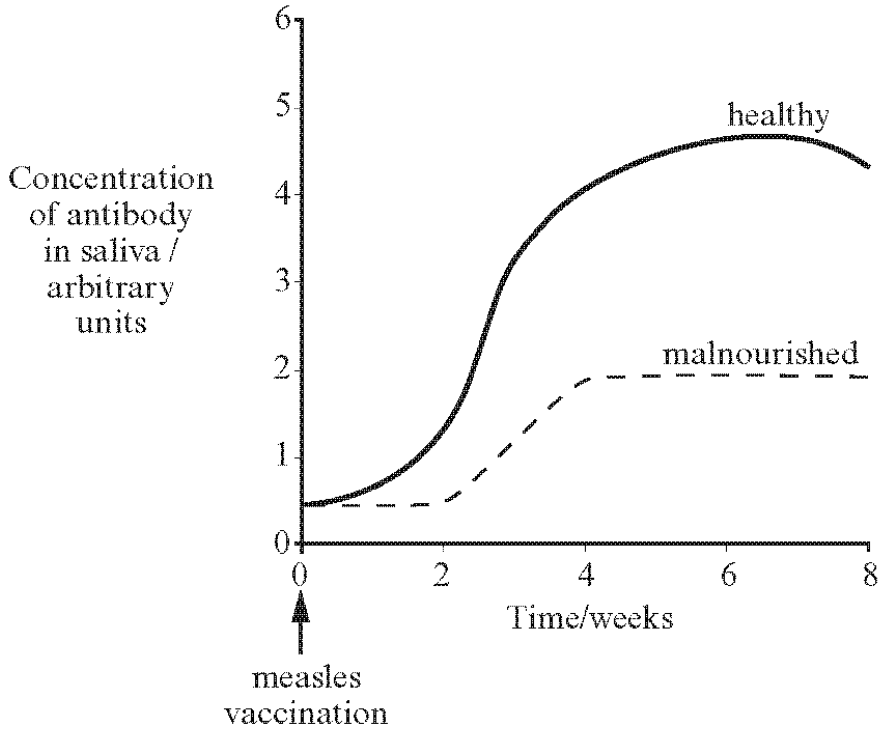
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11. *(a)* Large numbers of children continue to die from measles.
Children may now be vaccinated against measles.
The effectiveness of the vaccine varies according to diet.
The graph shows the level of antibody in a well fed child and a malnourished child over a period of eight weeks from the point of vaccination.



(i) Describe the differences between the graph antibody concentration for the 'healthy' and 'malnourished' child. [3]

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(ii) Suggest why there is a difference in the response for a malnourished child. [2]

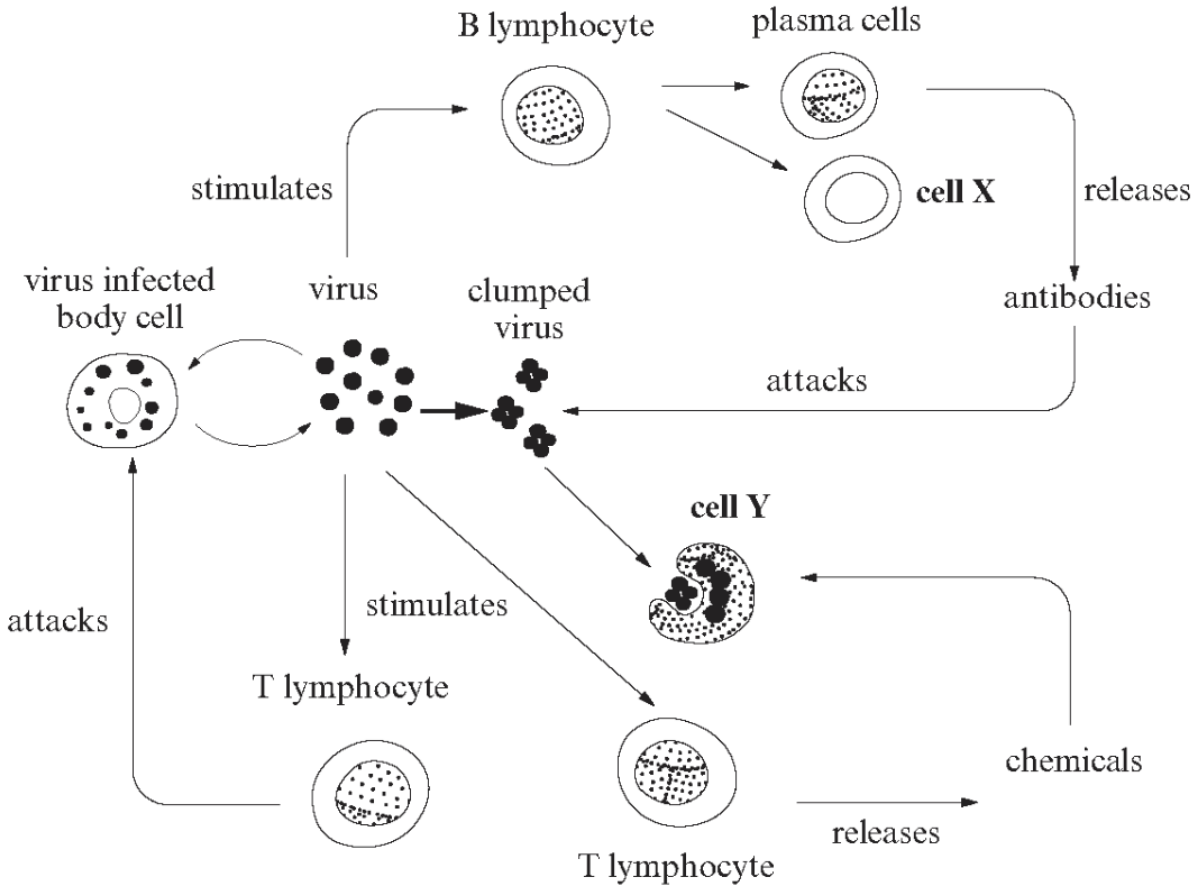
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(Total 5 Marks)

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12. The diagram shows some of the events occurring during the process of immunity.



(a) Name **cell X** and describe its function. [2]

Name .....

Function .....

(b) (i) With reference to the diagram, suggest why some T lymphocytes are referred to as *killer* cells. [1]

.....

(ii) What is the function of **cell Y**? [1]

.....

(iii) How do T lymphocytes affect the activity of **cell Y**? [1]

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(c) Describe how antibodies are specific to a virus. [1]

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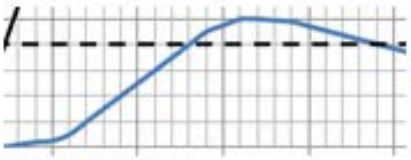
1.

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
1	(a)	(i)		Vector NOT carrier	1			1		
		(ii)		(Insect repellent/loose clothing/keeping windows closed and mosquito net) prevent mosquitoes biting (1) Not feeding (Avoiding stagnant water means) avoiding areas where mosquitoes breed (1) NOT hatching	2			2		
	(b)	(i)		**Any three (x1) from:** A. Viruses are not cellular so do not have metabolic pathways B. A vaccine would need to target {virus infected cells/ viruses directly when in tissue fluid/blood/outside cells} C. Viruses enter host cells so they avoid recognition by host immune system/drugs may not be able to get to virus D. Drugs would interfere with host cells metabolism or damage the host cells(1) E. Antigenic variation/ or description of/ drug resistance (1)		2	1	3		
		(ii)		Need **two** features for **1 mark** • Must be {safe/ not cause harm}/ not have side effects • must be effective/ trigger an immune response	1			1		
	(c)			Strategy **2** more effective in long term (1) **Any four (x1) from:** Number **1** • Advantage: Antibodies would act quickly/ confers immediate protection (1) • Placental transfer will protect the baby (1) • Disadvantage: no memory cells would be produced/ no long term immunity (1) Number **2** • Advantage: the production of memory cells (1) • Reference to herd immunity (1) • Disadvantage: would take longer to act (1)		1 1 1	1 1	5		
	(d)			Accept any value 34.5 - 43.9 = 2 marks If incorrect allow 1 mark for sight of Calculation 500/58 x **4** 500/58 x **5**		2		2	2	1
	(e)	(i)		Endemic: a disease, always present {at low levels (in an area)/ frequently at a predictable rate in a specific location/ population} (1) {Surgical patients – skin open to bacteria} / {Sick/elderly patients – low levels of immunity}/ ORA (1)	1	1		2		
		(ii)		{Inhibition of/ prevent/ stop} {protein synthesis/translation} (1) Humans have different ribosomes to bacteria (1)	1	1		2		
	(f)			**Any two (x1) from:** Not enough people (1) Only males (1) Only done on one ethnic group (1) Needs to be tested in infected individuals (1) Use of control group/placebo (1)			2	2		2
				Question 1 total	**6**	**9**	**5**	**20**	**2**	**3**

2.

Question Option A				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
2	(a)		(i)	A disease which is always present at low levels (in an area)/frequently at a predictable rate in a specific location/population (1) Epidemic – {significant/large} increase in the usual number of cases/rapid spread of infectious disease to a large number of people within a short period (1)	2			2		
			(ii)	sewage entered water supply (1) Cholera spread by drinking contaminated water/feco-oral route (1)	1	1		2		
			(iii)	Carriers/someone with the disease brought into Haiti			1	1		
	(b)		(i)	Antibodies are specific to an antigen (1) Different Strains would have different antigens (1) If no agglutination they different strains/if tested using antibodies to O1, O139 would not show agglutination/ORA(1)	1	2		3		
			(ii)	Identify the strain of *V.cholerae* in the peacekeepers in Haiti (1) Compare distribution of known strains in the {world/Nepal} to locate possible source (1)			2	2		2
			(iii)	**Any three (x1)from :** Antibiotics will pass through the gut before all bacteria killed (1) *V. cholerae* is Gram-negative and some antibiotics {less/not} effective/narrow spectrum (1) Kill bacteria but toxin remains (1) Antibiotic resistance (1)		1	2	3		
			(iv)	583/583.3(cm^3) 2 marks 200 x 70 = 1 mark 24		**2**		**2**	**2**	
	(c)		(i)	(First dose-) for a primary (immune) response **and** (Second dose) – for a secondary(immune) response (1) second dose acting as a booster/to increase antibody levels/increase memory cells (1)	**2**			**2**		
			(ii)	The vaccine would pass through the digestive system/ the vaccine would be in the intestine long enough/not {enough/all} absorbed/ vaccine could be broken down / stomach acid stops acid working/owtte		**1**		**1**		
			(iii)	**Any two (x1) from** Safety of the patients/side effects (1) Effectiveness /the vaccine might not work (1) costs/logistics of storage issues (needing cold conditions) (1)		**2**		**2**		**1**
				Question 2 Option A total	**6**	**9**	**5**	**20**	**2**	**3**

3.

Question			Marking details	Marks Available
3.	(a)	(i)	12.5 (days)	1
		(ii)	Memory cells already present; Less antigen needed to stimulate immune response; More plasma cells produced in a shorter period of time;	max 2
	(b)	(i)	(Approximately same shape as primary immune response:) **Start at 0** at 40 days;  **Some indication of a latent period + slow increase**; **Reaches a peak** similar to primary response after 13 – 17 days (day 53 – 57) then decreases;	3
		(ii)	No prior exposure to the antigen; Produces a primary immune response / no memory cells; Has to go through a latent period; Needs time to recognise foreign antigen / for clonal expansion / clonal selection / development of humoral response;	max 2
			Question 3 Total	**[8]**

4.

Question			Marking details	Marks Available
4	*(a)*		Endemic;	*1*
	(b)		carrier;	1
	(c)		vector;	1
	(d)		bacteriostatic;	1
	(e)		Infectious;	1
			Question 4 total	**[5]**

5.

Question			Marking details	Marks Available
5	*(a)*		sanitation/ safe disposal of sewage/ good hygiene; provision of {clean/ safe} drinking water/ bottled water; vaccine; Reject-antibiotic use/ oral rehydration therapy	Max 2
	(b)	(i)	lipoprotein; lipopolysaccharide; (Accept: porins)	2
		(ii)	X= peptidoglycan/ murein;	1
		(iii)	red/ pink,	1
		(iv)	Penicillin prevents <u>formation</u> of {cross linkages/peptidoglycan} in cell wal; (Cholera) is a gram negative bacterium; therefore has <u>very little</u> peptidoglycan; lipopolysaccharide layer protects cell from penicillin action;	3
			Question 5 Total	**[9]**

6.

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
6	(a)			**Cells:** There are {more than 1 000 times/ many more} microbial cells {on /in} our bodies than human cells. (1) **Genomes:** There are {many different/ variety} bacterial {genomes/ species} within the human body. (1) **Protection:** They prevent {harmful microbes/ pathogens} colonising the human body and causing disease/ outcompete pathogenic bacteria. (1)	2	1		3		
	(b)	(i)		Any **three** (×1) from: {engulfs the foreign microbe/ ref to phagocytosis} (1) antigenic presentation. (1) The T-cell recognises the foreign antigen (1) T cells are then activated / undergo clonal expansion (1)		3		3		
		(ii)		Killer T cells – {cause lysis of/ destroy} {target cells/ named cells}. NOT kill (1) Helper T cells – co-operate with B cells to initiate antibody response/ secretes cytokines/ B cell activation (1) Memory T cells – remain {dormant/ in circulation} until host is exposed to antigen again/ initiate secondary immune response/owtte (1) Reject reference to antibodies except in relation to B cell activation.	3			3		
	(c)	(i)		Any **two** (×1) from It allows the antibody to {bend/flex/distort/change shape} in order (for both arms) to bind to different antigens (1) because antigens are different distances apart on the target cell (1) antigens on different cells / cause clumping/ agglutination of bacterial cells(1)			2	2		
		(ii)		IgM can bind to more antigen than IgG / so it can agglutinate more antigen/ bind to more antigen/ form larger clumps of antigen (1)			1	1		
	(d)	(i)		1.25×10^8 or 125 000 000 = 2 marks If incorrect award 1 mark for $\frac{25 \times 100000}{0.02}$		2		2	2	
		(ii)		Any **two** (×1) from flame mouth of test tube/ flask work near updraft of Bunsen burner use sterile {pipette/ equipment}/ flame {loop/ spreader} tilt lid of Petri dish/ owtte		2				2
		(iii)		Human body temperature to culture human pathogens			1			1
		(iv)		Any **two** (×1) from • Antibiotics are not specific/ Bacteriophage only infect specific bacteria (1) • antibiotics cause {side effects/ phages} / have no side effects/ no allergic reactions(1) • More chance of bacterial resistance with antibiotics/ Low chance of bacterial resistance to phage therapy (because bacteriophage can mutate as fast as bacteria). (1)	1	1		2		
		(v)		Any **one** (×1) from The bacteriophage mutates to make infection worse/ infect human cells. Cost vs effectiveness of treatment/ religious objections Unknown side effects (1)			1	1		
				Question 6 total	**6**	**9**	**5**	**20**	**2**	**3**

7.

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
7	(a)			**Both for one mark.** • Mucus traps (bacteria) **and** Cilia moves it NOT microvilli	1			1		
	(b)			• Penicillin {inhibits/stops} the formation of cross linkages (between molecules of peptidoglycan) (1) NOT break cross linkages • {The wall is weakened / when osmotic changes occur} the cells lyse (1) • (Gram negative) cell walls have extra layers of lipopolysaccharide/ lipoprotein (1)		3		3		
	(c)	(i)		**Any two (x1) from:** the temperature (of incubation) (1) the length of time <u>of incubation</u> (1) the thickness of the agar in the plates (1) plating density of bacteria/ uniformity of plating (1) pH/ oxygen levels/ species of bacteria/ nutrient concentration (1)			2	2		2
		(ii)		Largest {size of zone of inhibition / clear zone/ diameter/ radius/ area} (1)		1		1		
		(iii)		A,B,C are bacteriostatic **and** D is bactericidal (1) Accept description of modes of action If bacteriostatic: there will be growth/ If bactericidal: no growth/ dead (1)		1	1	2		
	(d)			**One from why:** Needs host cell {for reproduction/ for metabolic processes}(1) Virus has no organelles/ metabolic pathways of its own (1) Uses cell metabolic pathways for reproduction (1) **One from Effects:** Kills the cell by {cell lysis/ production of toxic substances (1)	2			2		
	(e)	(i)		0.35-0.40 **and** 1.5 (1) Ignore decimal places		1		1	1	
		(ii)		**Any three (x1) from:** • clonal selection B cell/ antigenic recognition/ antigenic presentation activating B cells(1) • B cell undergoes clonal expansion / mitosis of B cells/ cloning (1) • <u>Differentiates</u> into plasma cells (1) • that {secrete/ produce} the specific antibody (1)	2	1		3		
		(iii)		null hypothesis = There is no significant difference in the concentration of antibodies in the blood samples before and after vaccination/ any difference in the concentration of antibodies in the blood samples before and after vaccination is due to chance		1		1		
		(iv)		The null hypothesis should be rejected, there is a significant difference in concentration of antibodies (before and after the vaccines)/ only 5% probability that it is due to chance/ ORA		1		1		1
		(v)		1.4-1.6 Accept if subtract original concentration e.g. 1.6 – 0.4 = 1.2			1	1	1	
		(vi)		If **fourfold increase** is **less** than **or equal to** 1.5: = Yes successful If **fourfold increase** is **more** than 1.5: = Not successful (1) Mutation/ Antigen variability / change in nucleic acid base sequence / change in amino acid sequence of (glyco)protein / change in tertiary structure, or in shape of protein / existing antibodies do not match / new ones have to be produced (1)	1		1	2		
				Question 7 total	**6**	**9**	**5**	**20**	**2**	**3**

8.

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
8	(a)			A disease which is always present at low levels (in an area)/ frequently at a predictable rate in a specific location (1)	1			1		
8	(b)	(i)		A – disulphide bridge/disulphide bond B – Antigen binding site C – Light chain D – Heavy chain All 4 correct = 3 marks, 3 correct = 2 marks, 2 correct =1 mark	3			3		
		(ii)		Antigen –initiates an {immune response/production of antibodies} (1) Antigen-antibody complex- a <u>specific</u> antibody bound to an antigen/ complementary antibody (1)	2			2		
	(c)	(i)		<u>Memory cells</u> (must make IgG during the secondary response/ after second exposure/clonal expansion)(1)		1		1		
		(ii)		Any 2 x (1) from: • The bacteria may have antigenic variation/surface proteins / reference to mutations (1) • (IgM produced again as) no memory cells to new antigen (1) • Primary response each time (1)			2	2		
	(d)	(i)		Delay in detection of bacterial antigen /reference to latent period/clonal selection (1) IgG not produced straight away / IgG non existent until day 7/ Time is needed to produce and secrete antibodies (1)		2		2		
		(ii)		Any 5 x (1) from: A. Antibodies maybe already attached to the bacteria/antigen/ a substance within the plasma (1) B. Different strain of bacteria which is not recognised by the test (1) C. more than one type of antigen on the surface of the bacteria (1) D. antibodies not at detectable levels/ Variation amongst peoples' immune response/ colour change not detectable (1) E. Enzyme not functioning/denatured (1) F. lack of control of variables e.g. pH/ temperature/ volume of sample (1)		2	3	5		
	(e)	(i)		35-38 °C **and** it is a human pathogen/ similar to body temperature (1)		1		1		1
		(ii)		380/ 380.13/ 379.94 mm^2 = 2 marks Allow the following for 1 mark 380 (no units) $(22/2)^2$ x 3.14 = $(11)^2$ v 3.14 =		2		2	2	
		(iii)		The zone of inhibition is a perfect circle/ radius is the same all the way round (1)		1		1		
				Question 8 total	**6**	**9**	**5**	**20**	**2**	**3**

9.

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
9	(a)	(i)		Skin (connective tissue) / skin flora (bacteria)/ blood clotting / inflammation/ phagocytes / macrophage lysozyme/ stomach acid/ low pH in stomach **Any 3 for 1 mark**	1			1		
		(ii)		{Many organisms/ named organism} live {in/on} the (human) body	1			1		
		(iii)		Cell lysis / cell bursts	1			1		
		(iv)		Any **three** × (1) from: • {Macrophages/ phagocytes} {engulf virus infected cell / carry out phagocytosis}/ antigen presentation (1) • clonal expansion/ T cells {proliferate/divide many times} / (1) • Cytokines stimulate phagocytosis (1) • Killer T cells cause cell lysis (1)	1	2		3		
	(b)	(i)		• Antibiotics can act on {cell wall of bacteria/ or description of/ hydrolyse peptidoglycan} (1) • Antibiotics affect {metabolism/protein synthesis} by bacterial cell (1) • Viruses don't have a {cell wall / metabolism} so not affected by antibiotics (1)	2		1	3		
		(ii)		7250 (mg) (2) If incorrect award 1 mark for any combination of three parts of equation 25mg × 14.5 × 2 × 10		2		2	2	
		(iii)		Amoxycillin is bactericidal + {as the bacterial numbers are reduced / has killed bacteria} (1) Tetracycline is bacteriostatic + {as it has prevented replication/no cell death/cell numbers remain constant }(1)			2	2		
		(iv)		Any **two** × (1) from: Same {concentration/ dosage} of antibiotics (1) same composition of {culture media/agar}/ named constituent of {culture media/agar} (1) Same strain of *S. pyogenes* (1) pH (1) NOT incubation temperature/ oxygen		2		2		2
		(v)		Human pathogen / (close to human) body temperature		1		1		1
	(c)	(i)		• May be {rapid/ high} mutation rate in rhinovirus /antigens change/viruses are antigenically labile (1) • Many {strains/serotypes/ antigenic types} of rhinovirus (1) • Vaccines would need to contain antigens from all strains (to provide complete immunity) (1) • Each antigen must produce a strong immune response/be highly antigenic / be immunogenic(1)		1	2	3		
		(ii)		Religious objections/ safety fears/ side effects/ individual rights/ some people may be too ill for vaccination e.g. due to HIV-AIDS or Chemotherapy		1		1		
				Question 9 total	**6**	**9**	**5**	**20**	**2**	**3**

10. *(a)* gram negative; 1

(b) via faecal – oral route/faeces of infected person to mouth of uninfected person/via contaminated water/food/flies; 1

(c) water not absorbed/reabsorbed/water lost from body;
low conc. of solutes/ions in blood;
low blood volume;
dehydration;
poor nerve conduction;
poor heart activity/failure; 3

(d) sewage treatment/ better sanitation;
clean water supply/chlorination;
good food hygiene;
transmission cycle broken; 2

(e) (i) stops growth/division/protein synthesis; 1

(ii) resistance of bacterium; Reject immune
can recover with ORT only; 2

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11. (a) (i) reaches maximum later/ quicker response/ longer latent period; — 3 max

higher maximum/ more antibodies (in saliva);

decreases after 6/7 weeks;

ref. comparative figures;

(ii) antibodies made of protein; — 2 max

required to make new antibodies/ lack of protein/ no or fewer antibodies;

process is energy dependent;

(Total 5 marks)

12.

(a)	memory cell;	**1**
	Allows fast/greater production of antibodies/ secondary immune response will be quicker when encountered again (not: responds quicker unqual.)	**1**
(b) (i)	Killer cells kill/destroy foreign cells/bacteria/cells infected with virus (not-kills virus/attacks virus infected body cell)	**1**
(ii)	Phagocytosis/engulf virus or ingests/digests/engulf pathogens	**1**
(iii)	Stimulate phagocytosis/activity of cell Y/produces more phagocytes (not: triggers….)	**1**
(c)	Complementary shape of virus and (variable region of) antibody enabling them to join/fit together/Any concept of binding sites	**1**
		(Total 6 marks)