IB · HL · Biology

3 hours 27 questions

Structured Questions

Defence Against Disease

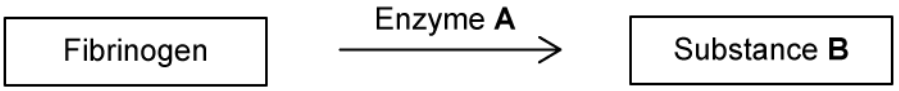
Pathogens / Barriers to Pathogens: Skin & Mucous Membranes / Blood Clotting / The Immune System / White Blood Cells / Adaptive Immune Response / HIV & AIDS / Antibiotics / Antibiotic Resistance / Zoonoses / Vaccines & Immunity / Evaluating COVID-19 Data: Skills

Easy (9 questions)	/56
Medium (8 questions)	/59
Hard (10 questions)	/89
Total Marks	**/204**

Scan here to return to the course
or visit savemyexams.com

Easy Questions

1 (a) The following diagram shows part of the blood clotting cascade.



Enzyme **A** acts on fibrinogen.

Identify enzyme **A**.

.....

(1 mark)

(b) Substance **B** is an insoluble protein formed by fibrinogen.

(i) Identify substance **B**.

[1]

(ii) State the purpose of substance **B** in the body.

[1]

.....

.....

(2 marks)

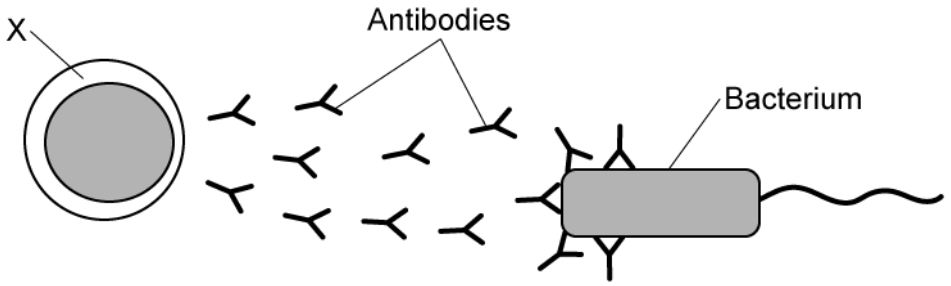
(c) Blood clotting is essential for the healing of wounds, but can be life-threatening if it occurs in the coronary arteries.

Define the term 'coronary arteries'.

.....

(1 mark)

2 (a) The diagram below shows the production and role of antibodies in the body.



Antibodies are produced by cell **X**.

Identify cell **X**.

.....

(1 mark)

(b) Antibodies are produced in response to the antigens present on pathogens.

Define the term 'antigen'.

.....

(1 mark)

(c) Antibodies are short-lived, but memory cells remain to provide long term immunity against a second infection by the same type of pathogen.

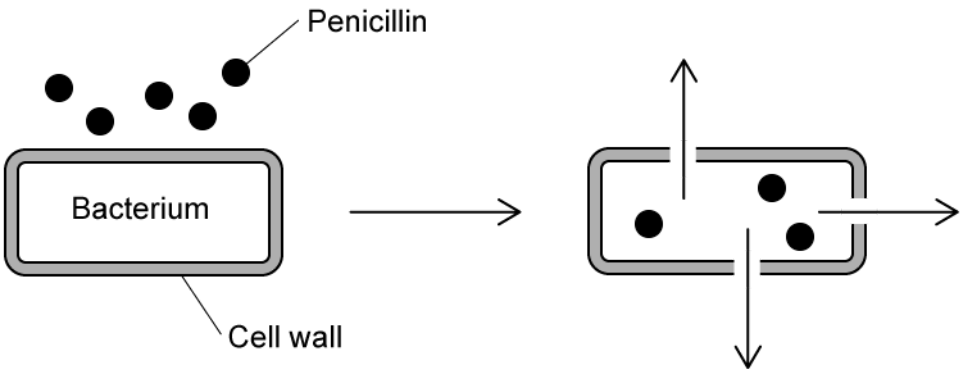
Describe the secondary response of the memory cells during an infection by the same type of pathogen.

.....

.....

(2 marks)

3 (a) The diagram below shows the action of penicillin on the bacterial cell wall.



Penicillin is an example of an antibiotic.

Define the term 'antibiotic'.

.....

(1 mark)

(b) Penicillin is an example of a commonly used antibiotic. It is produced naturally by a fungus (*penicillium*) to kill competing bacteria in their environment.

Based on the information in the diagram in part a), state the way in which penicillin kills bacteria.

.....

(1 mark)

(c) Other than the process stated at part b), list **two** processes in prokaryotic cells that antibiotics may target.

.....

.....

(2 marks)

(d) Antibiotics are not effective against viruses since they lack the structure and mechanisms of prokaryotic cells. Certain viral diseases are treated with substances known as antivirals.

State the way in which an antiviral works.

.....

(1 mark)

4 (a) Skin is the largest organ of the body and forms part of the primary defence against pathogens.

List **two** ways in which the skin defends the body against pathogens.

.....

.....

(2 marks)

(b) Platelets are very important in maintaining the integrity of broken skin as a barrier.

Define the term 'platelet'.

.....

(1 mark)

(c) Platelets are essential in the process of blood clotting.

State the role of platelets in response to blood vessel damage.

.....

(1 mark)

5 (a) Human immunodeficiency virus (HIV) is mainly transmitted by the direct exchange of body fluids.

List **four** ways in which HIV can be transmitted between hosts.

(4 marks)

(b) Once micro-organisms enter the body, white blood cells called phagocytes will provide the next line of defence.

Outline the way in which phagocytes provide defence against micro-organisms.

(4 marks)

(c) An HIV infection will eventually progress into AIDS.

Outline the development of AIDS from an HIV infection.

(5 marks)

6 (a) Antigens are molecules which trigger an immune response in the human body.

Complete the table by adding a **(✓)** to show which of the features is true for antigens.

Feature	A feature of antigens (✓)
Allow cell-to-cell recognition	
Can be glycolipids or glycoproteins	
Found on the surface of all pathogens only	
Responsible for allergic reactions	
Produced by activated B-lymphocytes	
Trigger complement proteins	

(3 marks)

(b) Blood donors who have blood type O- are considered 'universal donors' meaning they can donate blood to recipients of all other blood types without causing agglutination of the blood.

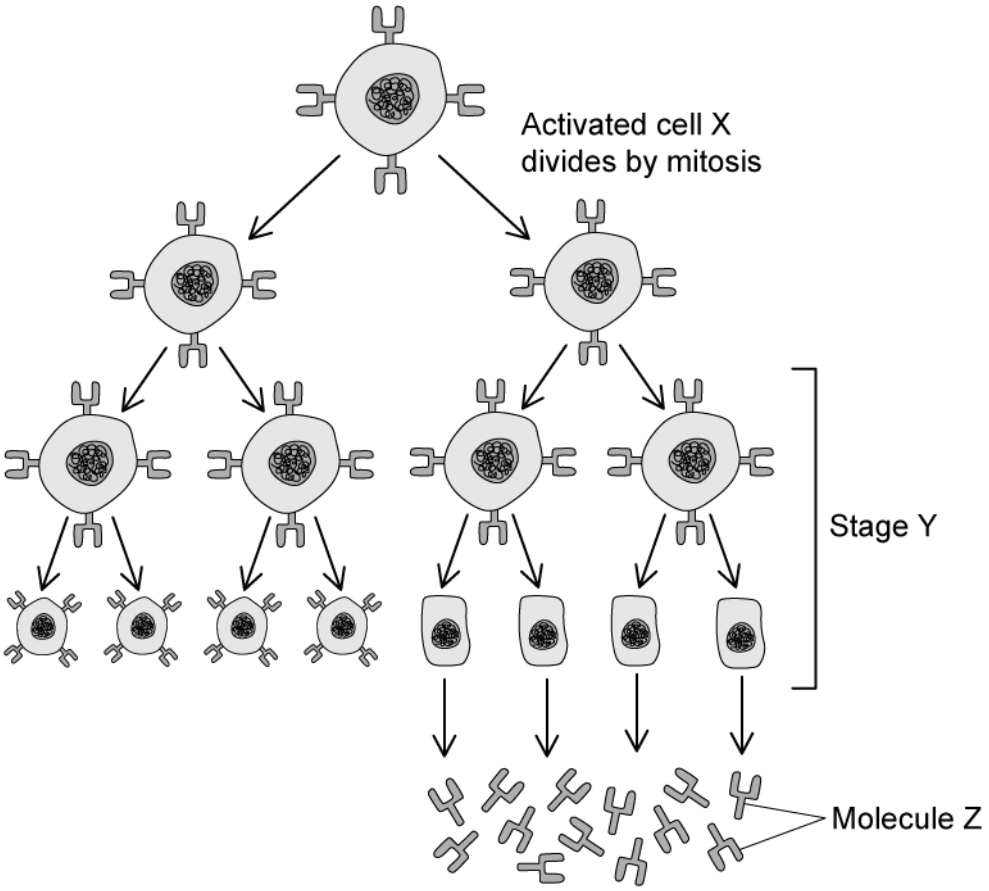
Which blood type is a universal receiver of blood?

(1 mark)

(c) State what component of a blood cell determines blood group of an individual.

(1 mark)

7 (a) The image shows part of the specific immune response.



(i) Identify the cell type represented by cell **'X'**

[1]

(ii) Identify the molecules labelled **'Z'**

[1]

.....

.....

(2 marks)

(b) Name the stage **Y** from the image in part **a)** and describe what occurs during this stage of the immune response.

.....

.....

(2 marks)

(c) Give two ways in which an innate immune response is different to an adaptive immune response.

.....

.....

(2 marks)

(d) Name one component of the innate immune response.

.....

(1 mark)

8 (a) Vaccinations are given to individuals in order to trigger a specific immune response.

Some vaccines contain attenuated versions of pathogens.

(i) State why attenuation is important.

[1]

(ii) What is meant by a specific immune response?

[1]

.....

.....

(2 marks)

(b) Some new diseases originate from animal populations and so current vaccines would not be effective in preventing infection.

(i) What is the term given to diseases which are able to cross the species barrier

[1]

(ii) Give **two** examples of diseases which have crossed the species barrier.

[2]

.....

.....

.....

(3 marks)

(c) Explain why current vaccines could not provide immunity from new diseases which may have crossed the species barrier or mutated from previously encountered diseases.

.....

.....

.....

(3 marks)

9 (a) Smallpox was a deadly disease caused by a pathogen which was finally eradicated in 1980.

Define the term pathogen. [1]

.....

(1 mark)

(b) Under current legislation, the methods by which Edward Jenner developed the vaccination for smallpox would not be approved by the Research Ethics Committee.

Indicate with a (✓) which of the following statements correctly identifies a reason why Jenner's methods would not have been accepted.

Statement	(✓)
Jenner observed the response of milkmaids to infection of cowpox	
Jenner carried out tests on animals before investigating the effects on humans	
Jenner infected a child with smallpox prior to using his vaccination	
Jenner did not carry out laboratory research	
Jenner hypothesised that milkmaids would not be affected by smallpox	
Jenner created a cowpox vaccination which successfully gave a 9-year old boy immunity to smallpox	

.....

.....

.....

(3 marks)

(c) Smallpox was eventually eradicated in 1980 as a result of a global eradication program implemented by the World Health Organisation.

The success of the program was attributed to many factors.

Describe two features of the program which resulted in its eventual success.

.....

.....

(2 marks)

Medium Questions

1 (a) Describe how mucous membranes form a primary defence against pathogens that cause infectious disease.

(3 marks)

(b) When the skin is cut microorganisms may enter the body. One defence against this is blood clotting.

Outline the cascade of events that results in blood clotting.

(5 marks)

(c) When a blood clot forms in the coronary arteries it is called a coronary thrombosis.

The table shows data on the number of deaths from coronary thrombosis in the UK.

Year	Number of deaths from coronary thrombosis
2012	562
2014	554
2016	545
2018	538
2020	529

Predict the number of people who died in 2022 if the trend remained the same.

.....

(1 mark)

2 (a) Outline the difference between antibodies and antigens.

(2 marks)

(b) The human immunodeficiency virus (HIV) can cause an immune response in its host.

Describe and explain the effect of HIV on the immune system.

(2 marks)

(c) Rhinoviruses that cause the common cold may be destroyed by phagocytosis when they enter a human body.

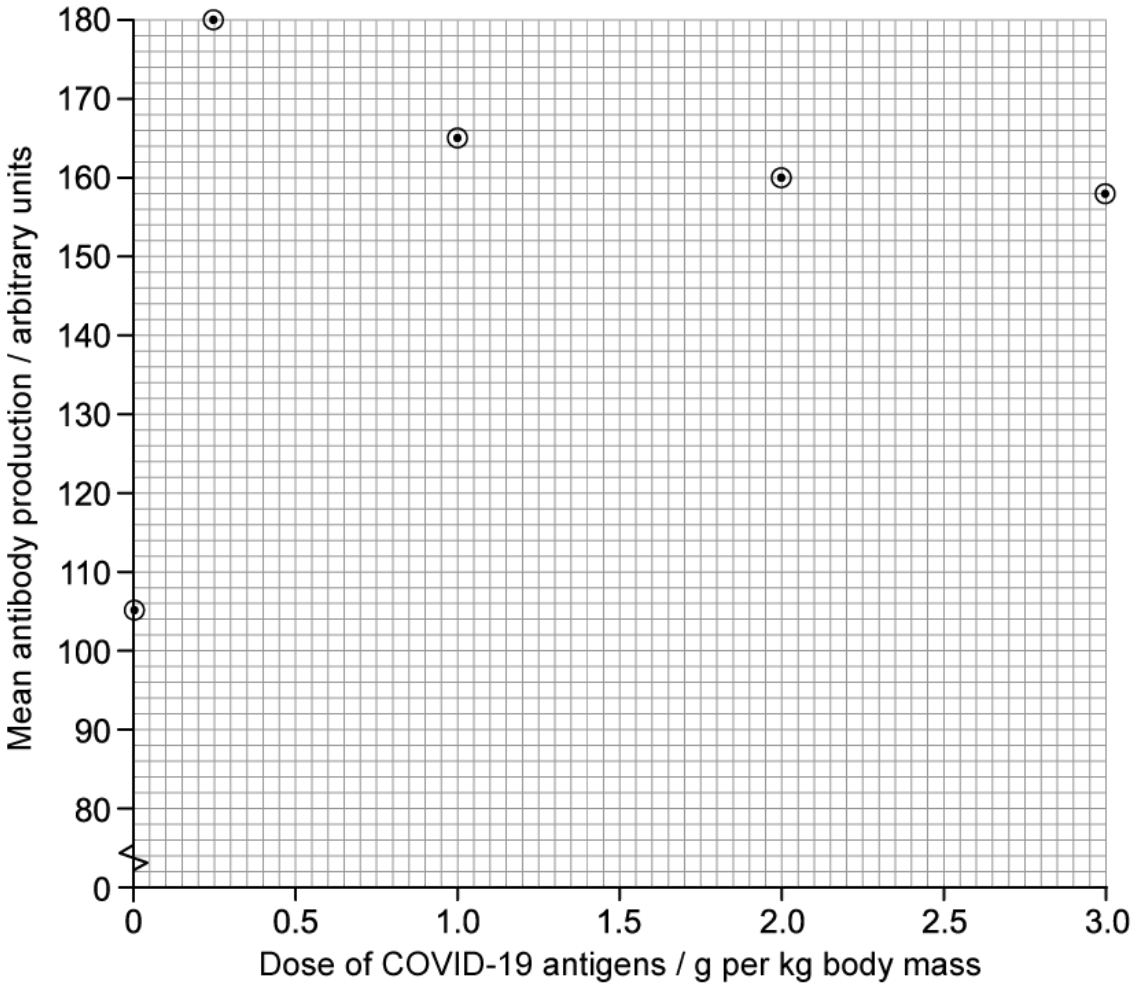
Describe how this occurs.

(4 marks)

(d) Vaccinations often contain antigens. Scientists investigated whether having a fourth Covid-19 vaccination booster could increase antibody production by the immune system.

- They divided a large number of mice into five groups.
- They injected the mice in each group with a different amount of COVID-19 antigens.
- The scientists then measured mean antibody production in the mice.

The graph below shows their results.



Use the graph to describe the effect of COVID-19 antigens on mean antibody production.

.....

(1 mark)

3 (a) Scientists investigated the presence of bacteria resistant to the antibiotic tetracycline in poultry and in the farmers who kept them. They looked for *Escherichia coli (E.coli)* resistant to tetracycline. The scientists took samples of faeces from the poultry birds and the farmers. Turkey farmers often used food containing tetracycline, whereas chicken farmers did not very often.

The bacteria were grown on nutrient agar containing tetracycline. Resistant bacteria grew and were visible as colonies on the agar plates.

The results are shown in the table below.

Sample taken from	**Percentage of samples from faeces containing *E.coli* resistant to tetracycline**
Chickens	26
Chicken farmers	9
Turkeys	83
Turkey farmers	56

Suggest a hypothesis the farmers were testing in this investigation.

.....

(1 mark)

(b) Describe the results of the scientists' investigation described in part **(a)**.

.....

.....

(2 marks)

(c) Scientists investigated treatment of a human respiratory infection caused by a species of bacterium. This species of bacterium is often resistant to the antibiotics currently used for treatment. They investigated the use of a new antibiotic to treat the respiratory infection. The new antibiotic blocks DNA replication in bacterial cells.

The scientists tested the new antibiotic on mice with the same respiratory infection. The antibiotics were given to the mice at a dose of 25 mg kg^{-1} per day.

Calculate how much antibiotic would be given to a 33 g mouse each day.

.....

.....

(2 marks)

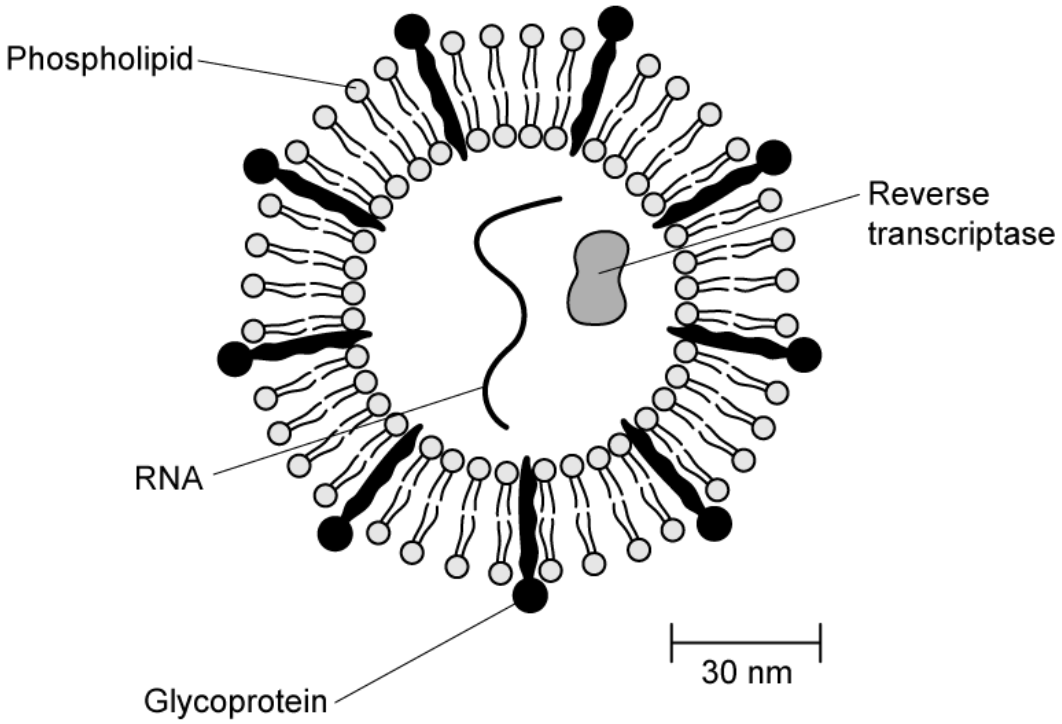
(d) The antibiotic tetracycline is used to treat human bacterial infections such as pneumonia and other respiratory tract infections. This antibiotic is safe to use in humans as it does not inhibit or block processes such as DNA replication, ribosome function, transcription or translation.

Suggest why these processes are not inhibited in humans but can be in bacteria.

.....

(1 mark)

4 (a) The diagram shows a human immunodeficiency virus (HIV).



Suggest, with a reason, which labelled component of the virus is most likely to act as an antigen.

.....

.....

(2 marks)

(b) HIV is described as a retrovirus.

Describe what is meant by the term retrovirus.

.....

.....

.....

(3 marks)

(c) Antibiotics are **not** used to treat viral infections, such as HIV.

Explain why.

.....

(1 mark)

(d) Misuse of antibiotics can cause antibiotic resistance.

Outline two ways to prevent antibiotic resistance.

.....

.....

(2 marks)

5 (a) Define the term 'antigen'.

(2 marks)

(b) In humans the ABO system of blood typing is based on red blood cell antigens. The table below contains some information about the antigens involved in ABO blood types.

Blood group	Antigens present on the surface of red blood cells	Could receive a blood transfusion from blood group(s):
A	Type A	A or O
B	Type B	**1**
AB	Types A and B	**2**
O	None	O

Identify the groups marked **1** and **2** from which blood groups B and AB could safely receive a blood transfusion.

(2 marks)

(c) Explain the blood transfusion options, shown in the table in part b), available to a person with type O blood.

(2 marks)

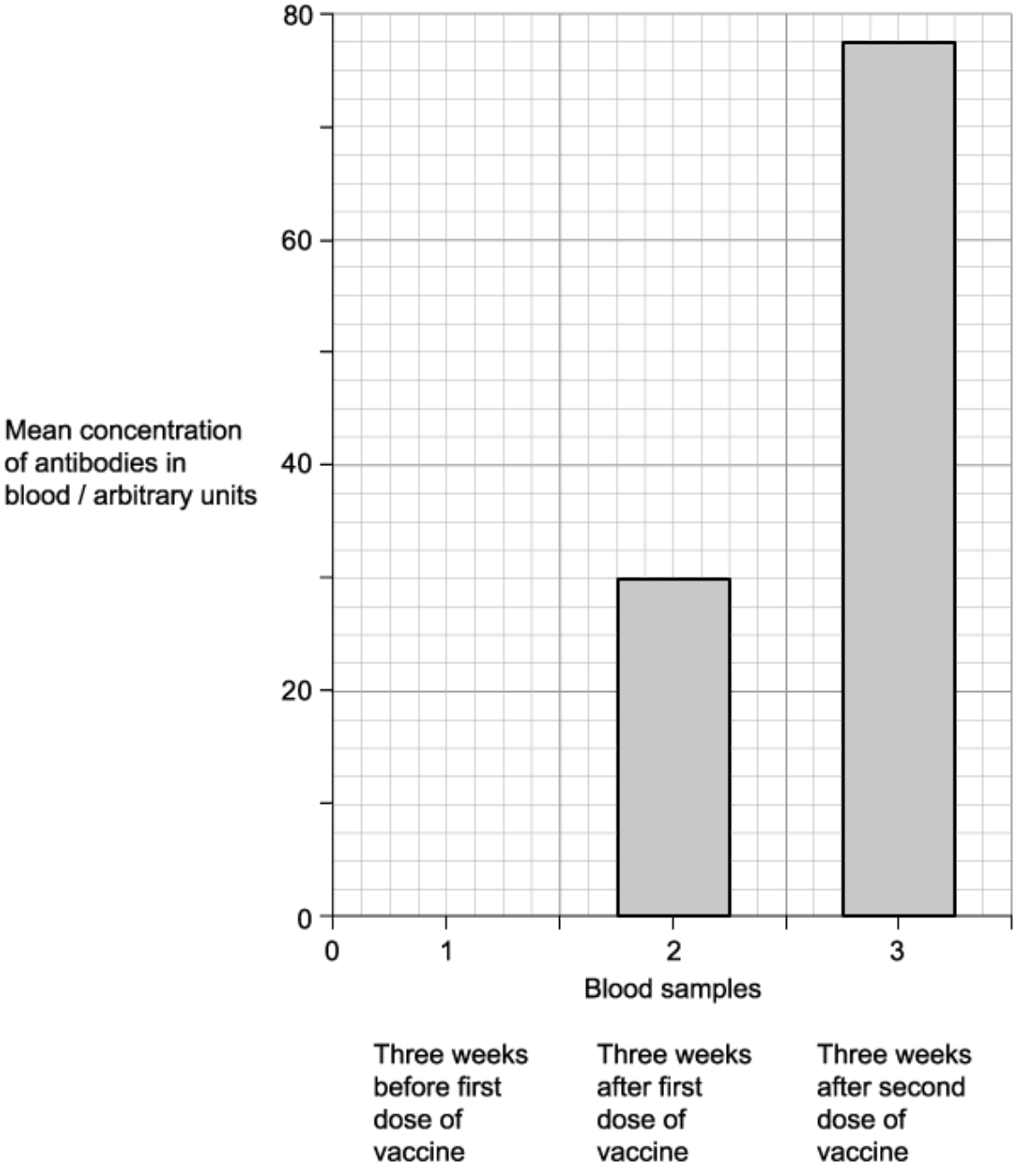
6 (a) A medical researcher vaccinated a group of adult patients against human papillomavirus (HPV). He gave each patient two doses of vaccine five months apart. The researcher tested three samples of blood from each of the patients for antibodies against HPV.

Sample 1: taken 3 week before the first dose of vaccine

Sample 2: taken 3 weeks after the first dose of vaccine

Sample 3: taken 3 weeks after the second dose of vaccine

The results are shown in the graph below.



Calculate the percentage increase in the mean concentration of antibodies in the blood between samples 2 and 3.

(2 marks)

(b) In a trial for a new, improved version of the vaccine in part a), a doctor gave the new vaccine to a group of adult volunteers, following the same procedures.

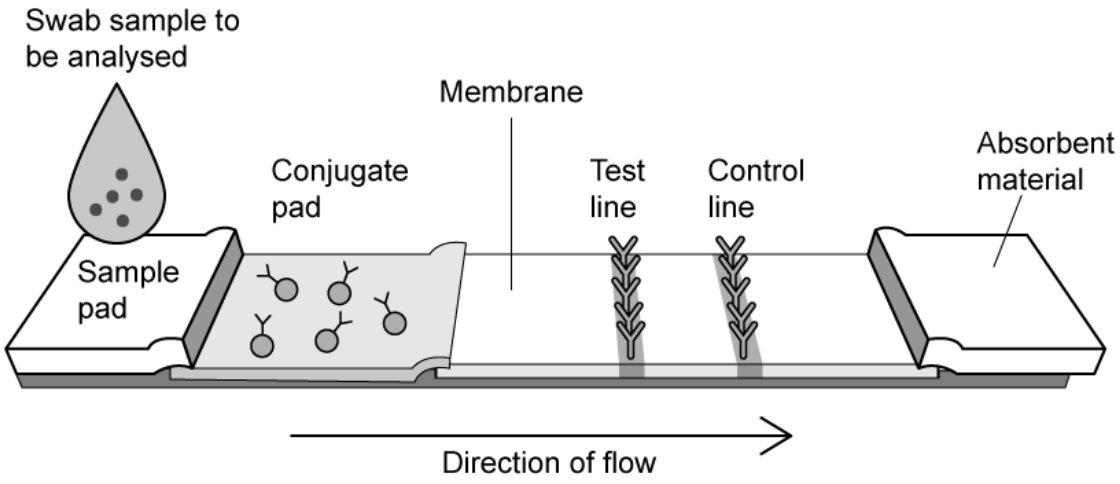
Suggest **two** factors the doctor should have considered when selecting adult volunteers for this trial.

(2 marks)

(c) Explain the differences in antibody concentration between the three blood samples in the graph in part a).

(4 marks)

7 (a) SARS-CoV-2 is the virus that causes COVID-19. The image below shows the structure of a rapid test strip used to test for the presence of SARS-CoV-2 antigens in a person's nose and throat cells.



Describe what would happen in the region labelled 'conjugate pad' if an individual infected with SARS-CoV-2 placed a sample on the sample pad.

.....

.....

(2 marks)

(b) Explain how the sample mentioned in part a) would give a positive result on the test line.

.....

.....

(2 marks)

(c) State the function of the control line on the test shown in part a).

.....

(1 mark)

(d) Several vaccines have been developed against SARS-CoV-2. One of the vaccines contains genetic material that allows an individual's cells to synthesis SARS-CoV-2 antigens.

Suggest how this vaccine initiates the specific immune response against SARS-CoV-2.

(2 marks)

8 *One mark is available for clarity of communication throughout this question.*

Explain how antibodies combat infection.

(6 marks)

Hard Questions

1 (a) Haemophilia B is a rare genetic disorder where the body produces very little or no factor IX, a protein that is responsible for a cascade of reactions resulting in the conversion of fibrinogen into fibrin.

Explain the effect of insufficient levels of factor IX on the process of blood clotting.

.....

.....

(2 marks)

(b) A person suffering from haemophilia B will be more prone to excessive bruising.

Based on the information provided, suggest a reason for this.

.....

(1 mark)

(c) Haemophilia B cannot be cured but one form of treatment involves injecting patients with factor IX, which is derived either from donated blood or artificially produced using genetic engineering.

Explain the importance of determining the correct dosage of factor IX before injecting patients.

.....

.....

(2 marks)

(d) In certain rare cases, the body may produce antibodies against factor IX that is injected during replacement therapy,

Suggest **one** effect these antibodies may have on the treatment.

.....

(1 mark)

2 (a) Lupus is an autoimmune disease in which the immune system will produce autoantibodies against the body's own tissue. This results in a variety of symptoms, including inflammation of the skin and organs to more serious ones such as organ failure and strokes.

Compare and contrast an autoimmune response to the immune response against a pathogen.

(2 marks)

(b) The symptoms of lupus can get progressively worse over time.

Based on your knowledge of lymphocytes, suggest a reason for this.

(2 marks)

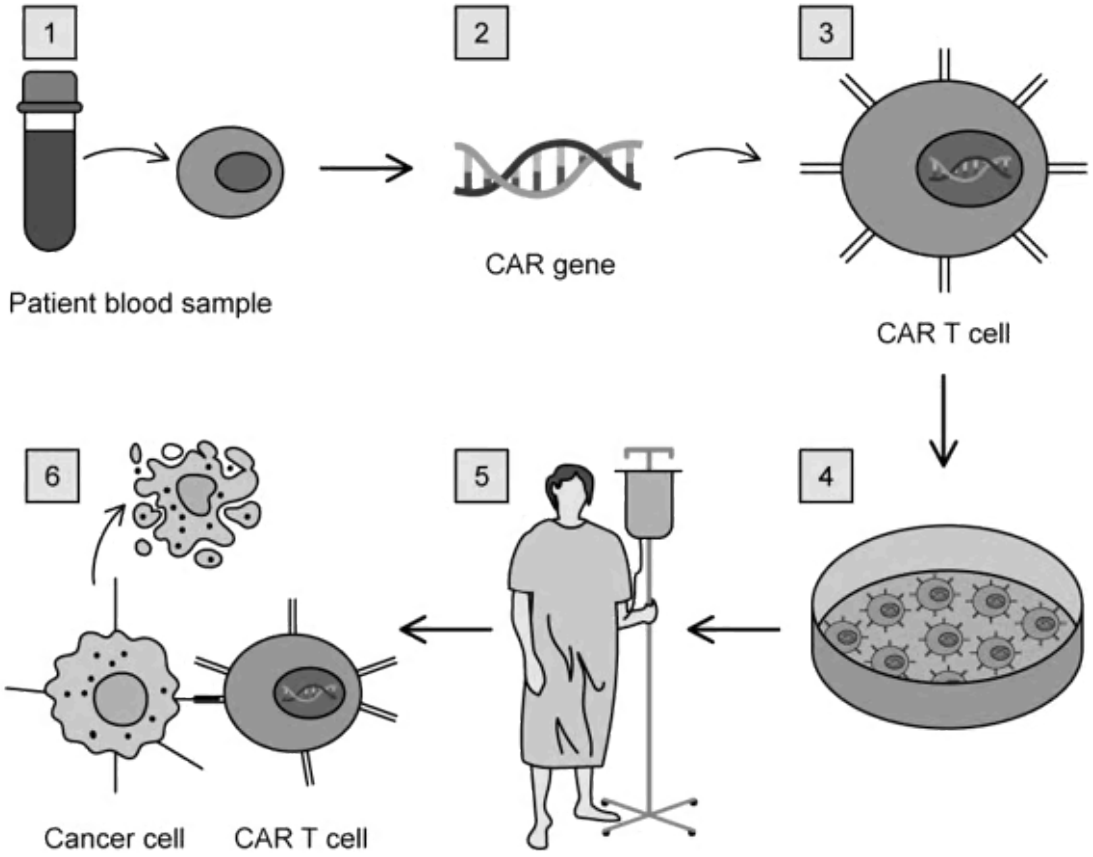
(c) There are a variety of ways to treat lupus. One form of treatment involves administering immunosuppressive drugs which prevents the activation of lymphocytes.

Explain the impact that this form of treatment could have on a lupus patient.

(2 marks)

3 (a) T-cells are another type of white blood cell that can help the body fight against infections. Instead of producing antibodies, T-cells will bind to the surface of infected or defective cells and destroy them directly. This ability has been harnessed in a new type of cancer treatment known as chimeric antigen receptor (CAR) T cell therapy.

During CAR T cell therapy, normal T cells from the patients blood are modified to enable them to bind to cancer cells with the help of cell surface receptors. The following diagram shows the treatment process of CAR T cell therapy.



Contrast the differences between a normal T cell (stage **1** of the diagram) and a CAR T cell (stage **3** of the diagram).

.....

.....

(2 marks)

(b) Using the information in the diagram in part a), suggest how CAR T cell therapy facilitates in the treatment of certain cancers.

(2 marks)

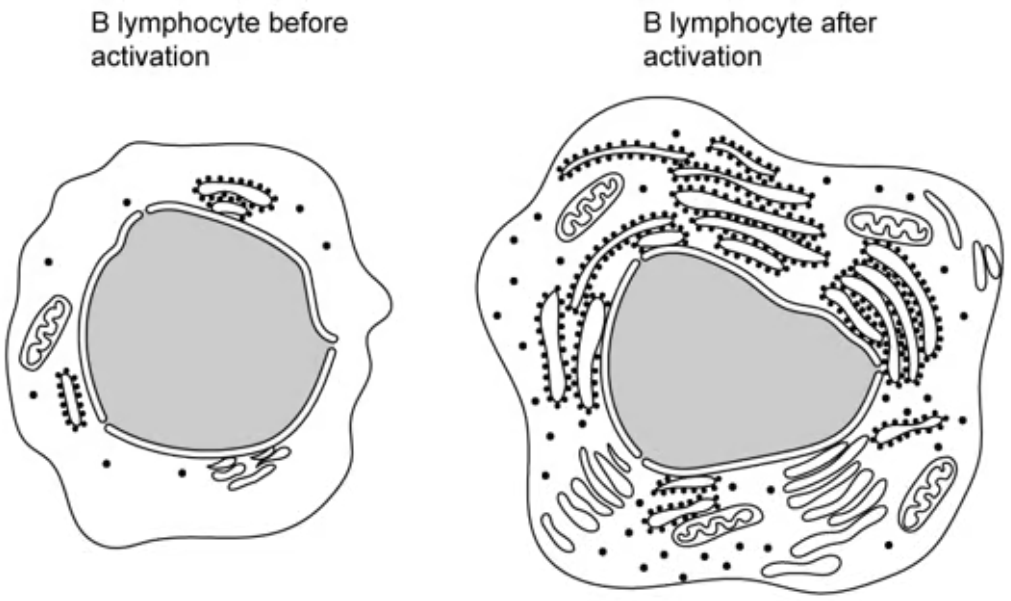
(c) Traditional forms of cancer treatment include chemotherapy during which toxic chemicals are inserted into the blood stream of a patient. These chemicals will circulate through the body and kill any fast-dividing cells, which often leads to uncomfortable side effects such as hair loss, nausea and skin rashes. The chemicals used during chemotherapy are broken down by the body and therefore have a short-lived effect, requiring patients to receive multiple treatments on a regular basis in order to be effective.

Based on the information provided and your knowledge of the immune system, suggest **two** advantages of CAR T cell therapy over chemotherapy.

(2 marks)

4 (a) B lymphocytes are a type of white blood cell. These lymphocytes produce antibodies in response to activation by the presence of an antigen on a pathogen.

The diagram below shows the appearance of a B lymphocyte before and after it has been activated.



Explain the changes that can be observed within the B lymphocyte when it is activated.

(3 marks)

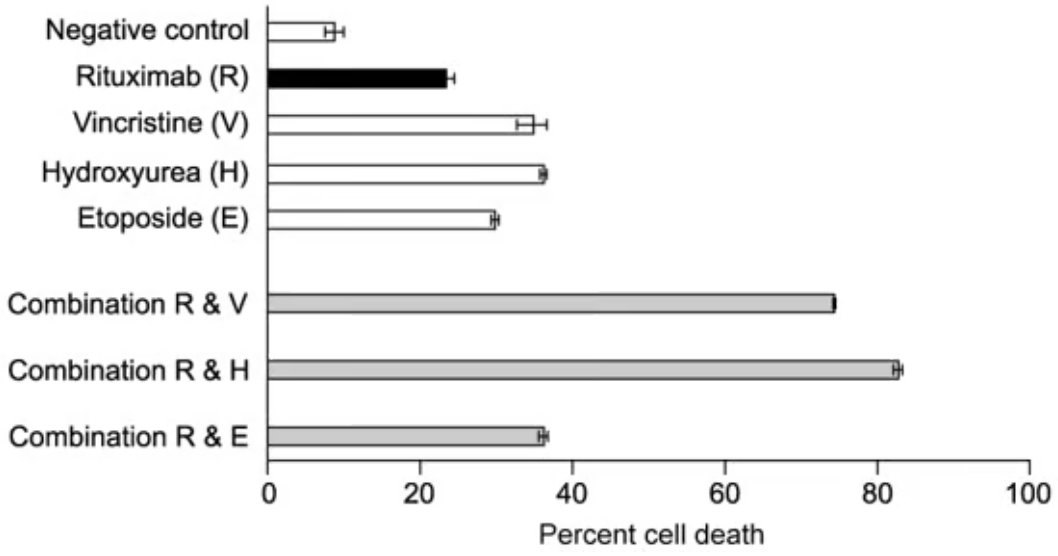
(b) Rituximab is a type of antibody that is used to treat certain B lymphocyte cancers (leukaemia). It binds to the cell surface protein CD20 found on B-lymphocytes. Once the antibody binds to the protein it triggers cell death in the cancerous B-lymphocyte. Patients are given rituximab through a drip into a vein on a regular basis for the duration of their cancer treatment.

Based on your knowledge of the immune system, explain why patients would need regular infusions with rituximab.

(2 marks)

(c) When treating more aggressive forms of B lymphocyte cancer, rituximab is often combined with more traditional chemotherapies.

The graph below shows the results of a trial looking at the effects of several different treatments, alone and in combination, on B lymphocytes grown in the laboratory.



Rituximab on its own killed 23% of the B lymphocytes while when combined with hydroxyurea it killed 82% of B-lymphocytes in the laboratory.

Calculate the percentage effectiveness of using rituximab in combination with hydroxyurea compared to rituximab on its own. Show your working and give your answer to three significant figures.

(2 marks)

(d) A medical doctor concluded that drug combinations are a more effective cancer treatment for human patients than any of the drugs used alone.

Use the information from part c) to evaluate this conclusion.

(3 marks)

5 (a) Phagocytes and lymphocytes play an important role in the immune system of the body.

Compare and contrast the role of phagocytes and lymphocytes in the immune system.

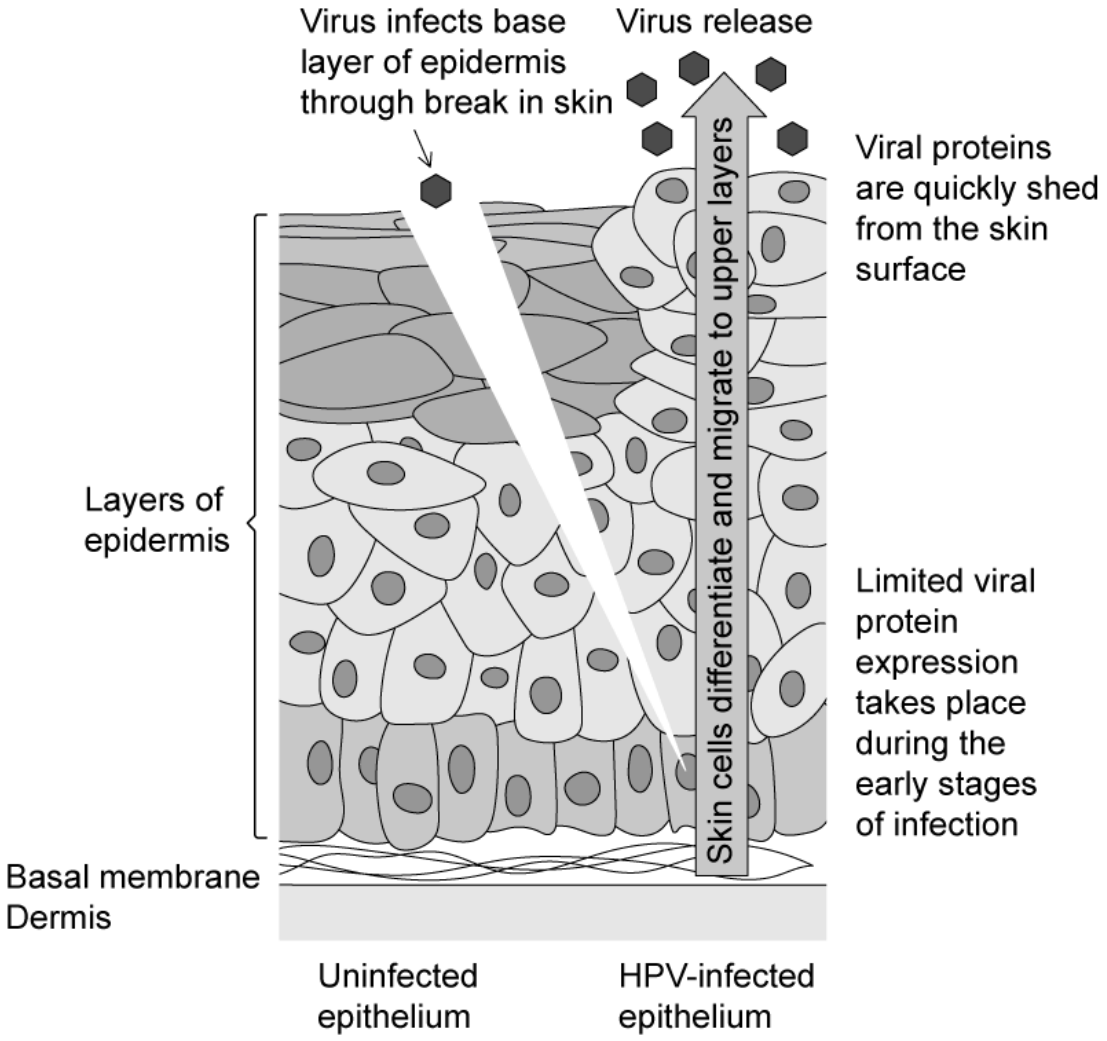
(5 marks)

(b) Certain species of bacteria may develop resistance to antibiotics over time.

Outline the development of antibiotic resistance in a bacterial population.

(7 marks)

6 (a) The image shows the progress of infection when damaged human skin comes into contact with Human Papillomavirus, or HPV.



It can be 6-12 months before HPV antibodies can be detected in the blood of an individual with a HPV infection. Use the information in the image to suggest why this is.

.....

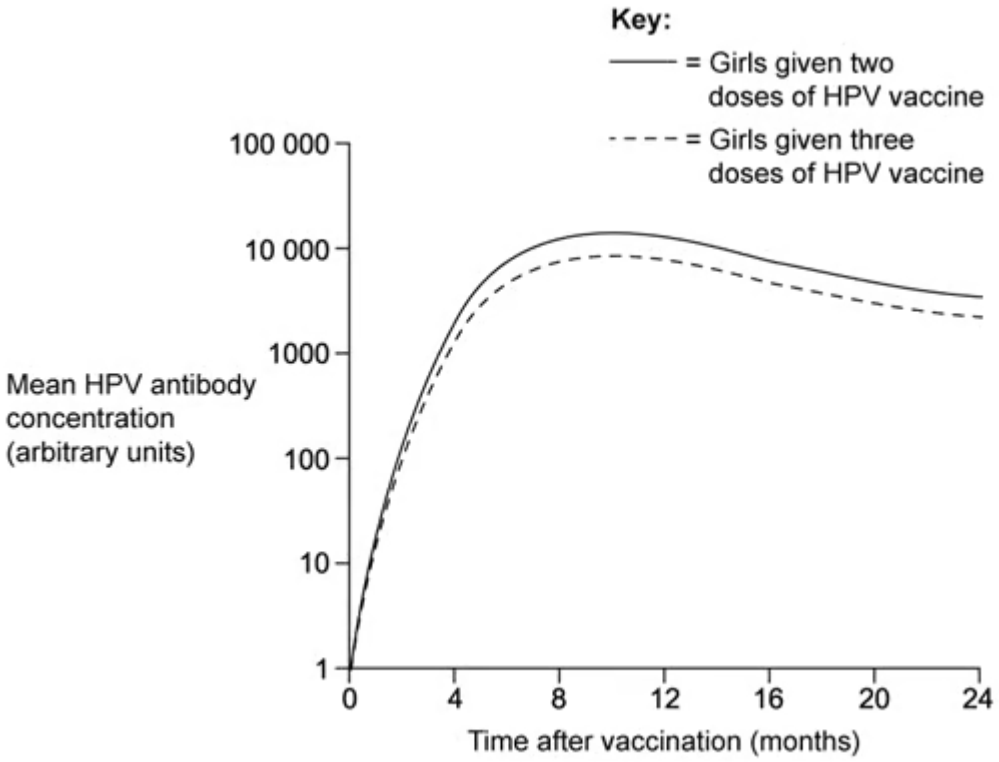
.....

.....

(3 marks)

(b) There is a vaccination for HPV which is routinely given to teenage girls, as it is thought to offer future protection against cervical cancer. The standard procedure is for each girl to receive three doses of the vaccine for full immunity, although there is some discussion about the optimum number of doses.

The graph below shows antibody production after different doses of the HPV vaccine in teenage girls.



A student concluded from the data that it didn't matter whether girls were given two doses of vaccine or three. Evaluate this conclusion.

.....

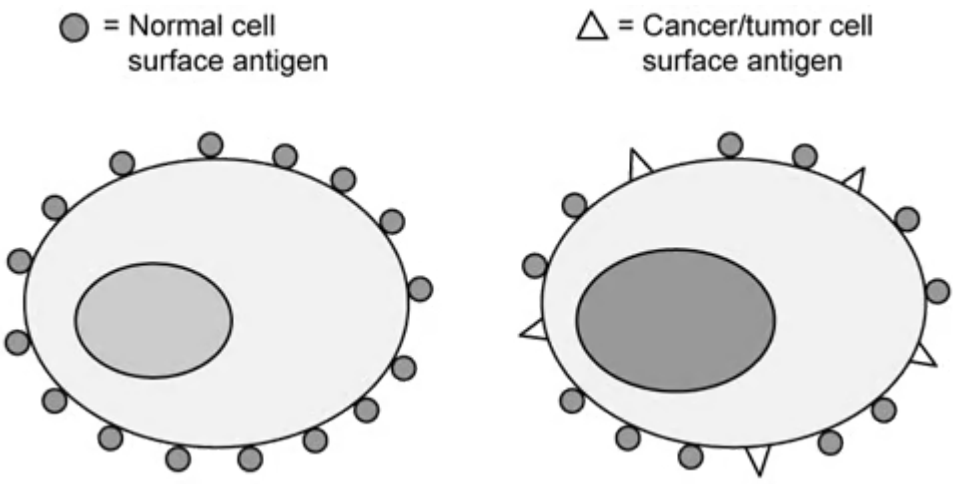
.....

.....

(3 marks)

(c) HPV vaccines provide protection against cancer by preventing the virus from causing mutations in infected cells. Current medical advances in vaccine technology mean that researchers hope that it will soon be possible to vaccinate people against cancer cells themselves.

The image shows some of the changes that can take place when a cell becomes cancerous.



Use the image to suggest how a vaccine could be effective against the development of cancer.

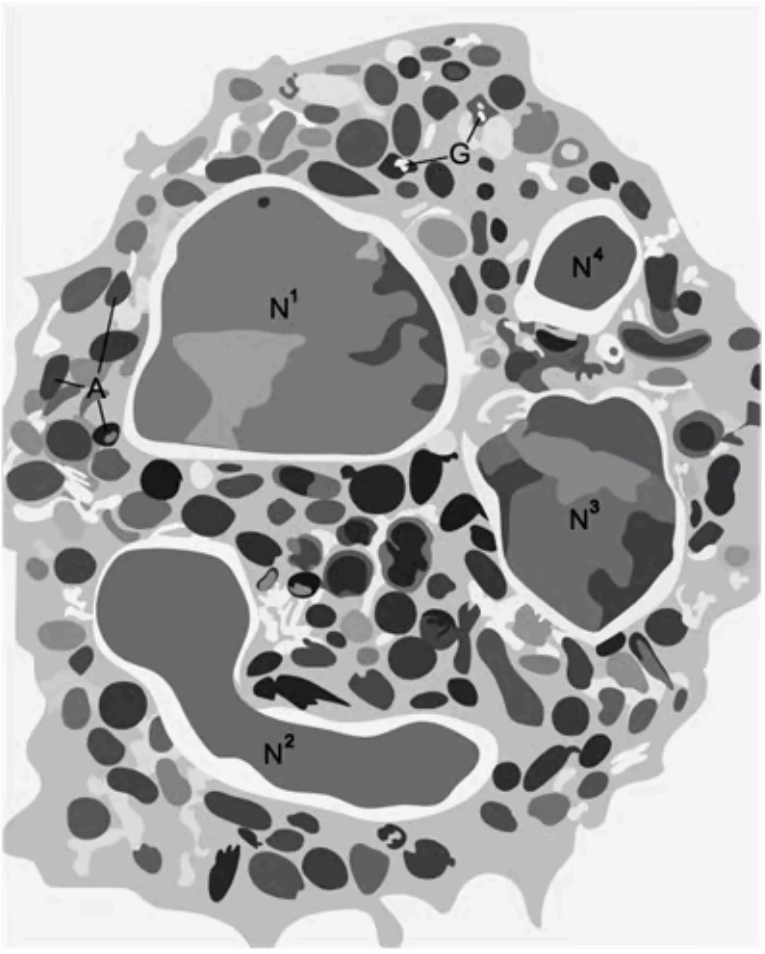
(4 marks)

(d) Development of an Ethics Research Committee marks a key change in the procedures involved in the development of new drugs, including vaccines, however, there are still issues associated with the modern methods described in part **d)**.

Suggest what ethical issues may be associated with these procedures.

(2 marks)

7 (a) This image shows a type of phagocyte called a neutrophil.



- **N1-N4**: multi-lobed nucleus
- **A**: Lysosomes
- **G**: glycogen granules

Use the image to explain how neutrophils are adapted for their role.

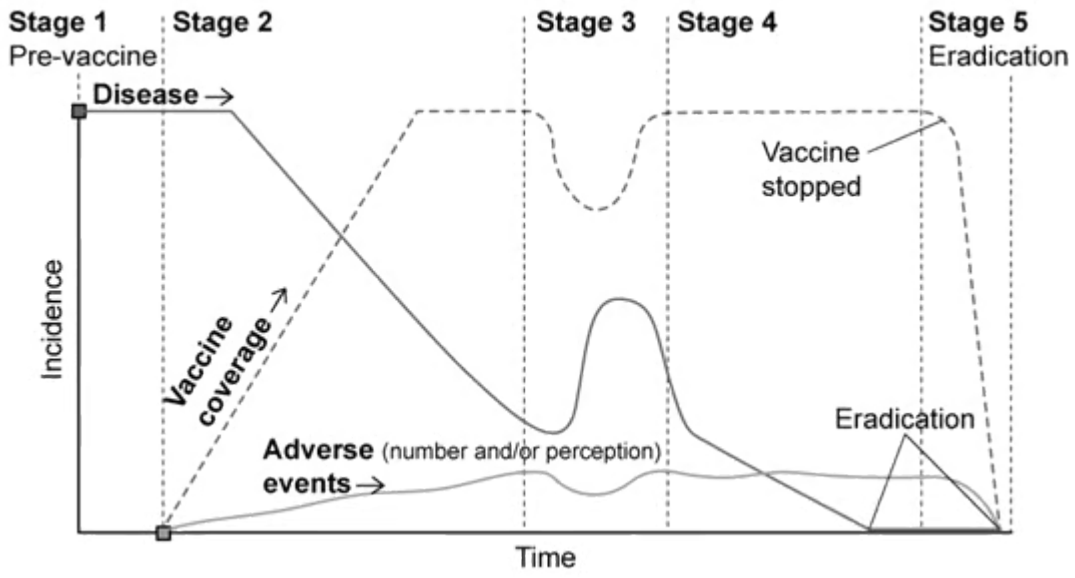
(3 marks)

(b) When pathogens enter the body, phagocytes carry out a process called phagocytosis, which is a non-specific response.

Outline the process of phagocytosis and explain how it eventually leads to a specific immune response in the infected individual.

(5 marks)

8 (a) The graph below shows the events that take place during the progression of a vaccination program



Suggest an explanation for the events seen in stage 3 of the vaccination program.

(4 marks)

(b) Towards the end of **stage 4** in the graph from part **a)**, the disease incidence drops to zero.

Explain what needs to happen within the vaccination programme to reach a disease incidence of zero.

(3 marks)

(c) In the 1850's a law was passed in the UK to make vaccination against smallpox compulsory in infants.

At this time, there was an estimated population of 27 368 800 and the birth rate was 35 live births per 1000 people.

The table shows the herd immunity thresholds for several different diseases.

Disease	Herd Immunity Threshold (%)
Smallpox	80-85
Measles	92-94
Polio	75-92
SARS	50-75
SARS-CoV-2 (COVID-19)	82-85

Of the diseases listed, only smallpox has been fully eradicated.

Calculate how many babies needed to be vaccinated to reach the herd immunity threshold suggested in the table.

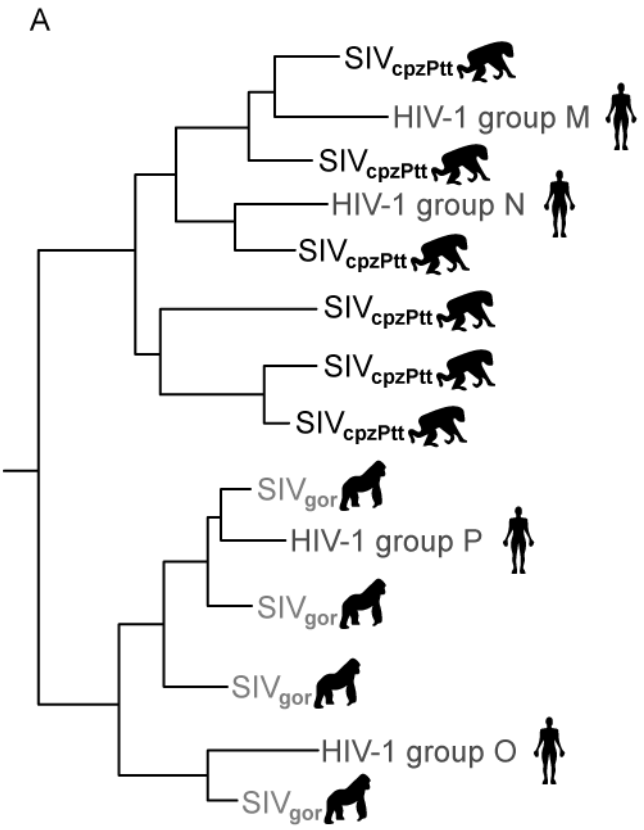
.....

.....

(2 marks)

9 (a) The image shows the evolutionary links between the simian immunodefficiency virus (SIV) and the human immunodefficiency virus (HIV).

Note that the image shows the evolution of two strains of SIV, one in chimpanzees (*cpzPtt*) and one in gorillas (*gor*).



Suggest what the image indicates about the emergence of HIV in human populations.

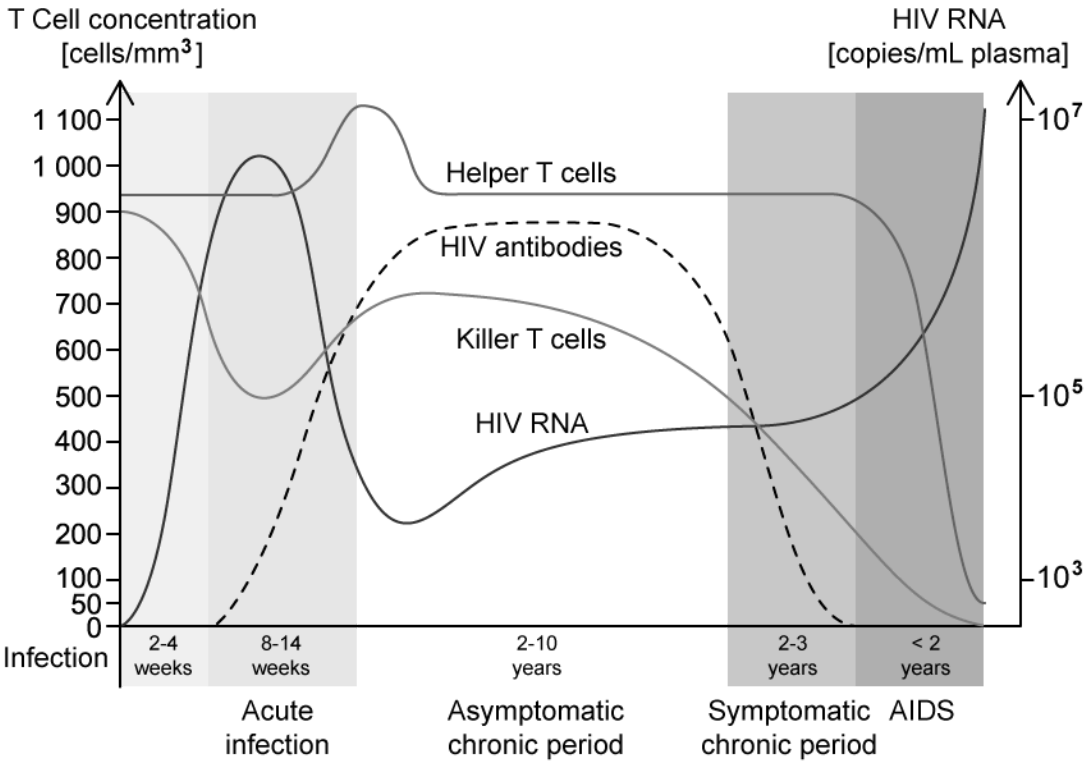
.....

.....

.....

(3 marks)

(b) The image shows some of the changes that take place in the blood after infection by HIV.



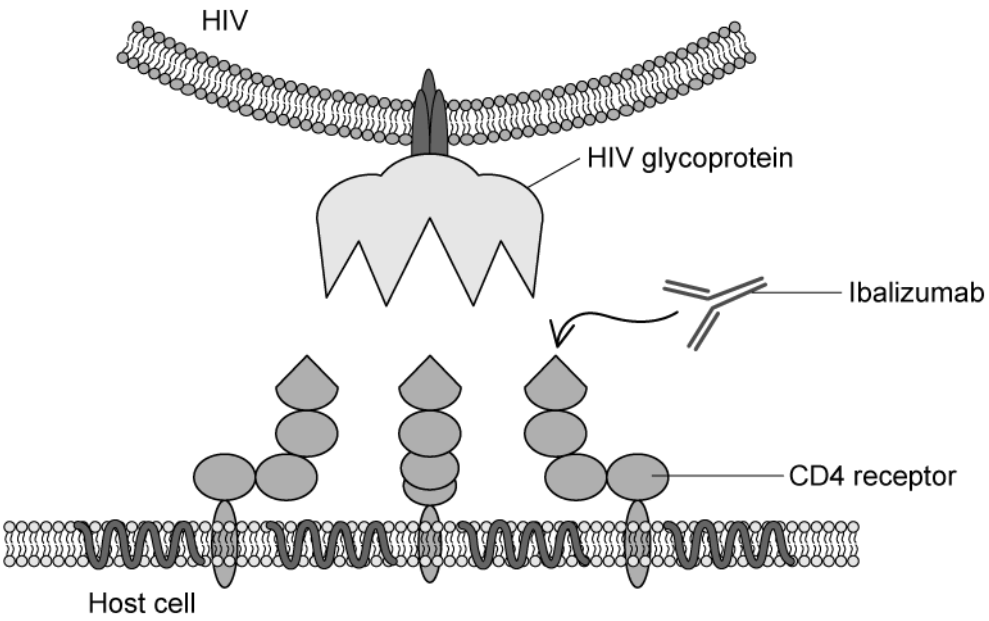
After 2 years since infection, HIV leads to the development of Acquired Immunodeficiency Syndrome (AIDS).

Use the information in the graph and your knowledge of the immune system to explain this.

(4 marks)

(c) HIV infects human T-cells by binding to a cell surface receptor called CD4. This binding causes a shape change in the viral surface glycoproteins, enabling the virus to enter the host cell.

A new treatment for HIV involves a monoclonal antibody called Ibalizumab, the action of which is shown in the diagram below.



Suggest how Ibalizumab works as a treatment for HIV

.....

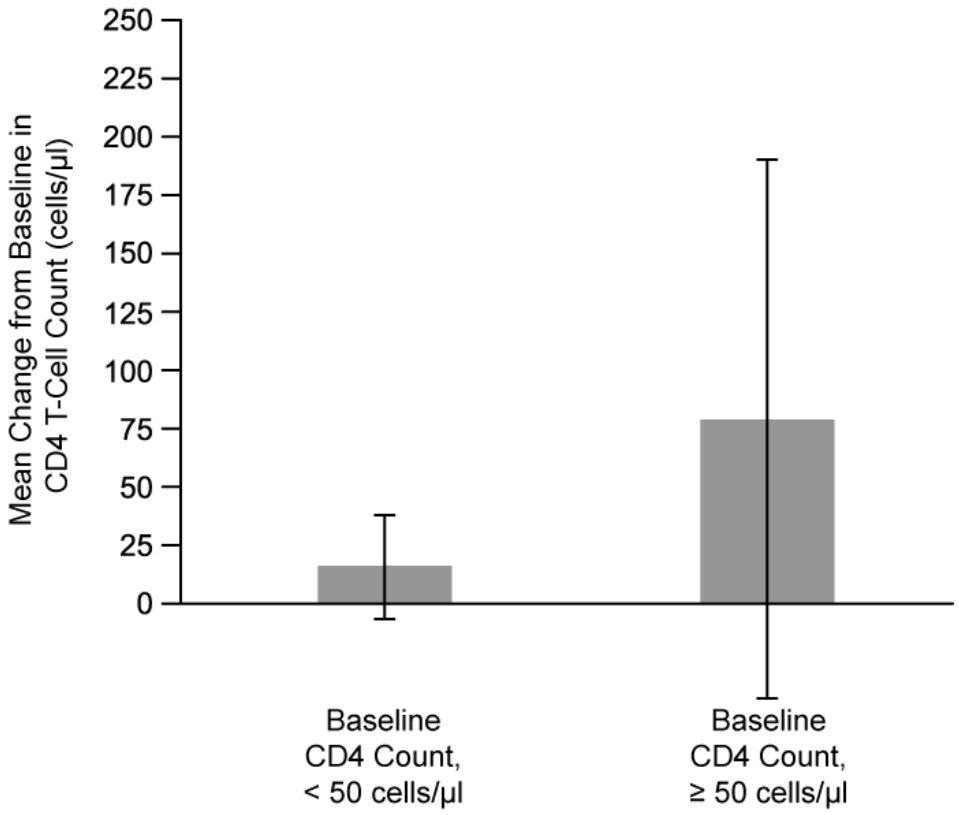
.....

.....

(3 marks)

(d) A trial looking at the efficacy of Ibalizumab investigated its impact on CD4 cell (also known as helper T cell) count after 25 weeks of treatment.

The results are shown in the graph and include the standard deviations for each group of patients.



State and explain what can be concluded about the efficacy of Ibalizumab from the results shown.

(3 marks)

10 (a) Describe and explain the changes that take place to the cell ultrastructure of a B-cell after activation to ensure it is adapted for its function.

(4 marks)

(b) In an immune response to a particular pathogen, a vaccinated individual recovered from the mild symptoms in 5% of the time experienced by a person contracting the pathogen for the first time.

A first-time sufferer typically suffers severe symptoms and takes 7 days to recover from the pathogen.

Calculate the vaccinated individual's recovery time. State your answer in hours and minutes.

(3 marks)