

Structured Questions: Paper 2

6.3 Defence Against Infectious Disease

6.3.1 Skin / 6.3.2 Blood Clotting / 6.3.3 White Blood Cells / 6.3.4 Antibiotics / 6.3.5 Antibiotic Resistance

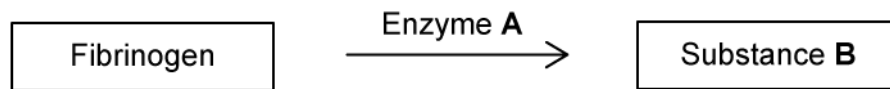
Easy (5 questions)	/34
Medium (5 questions)	/48
Hard (5 questions)	/40
Total Marks	/122

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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'.

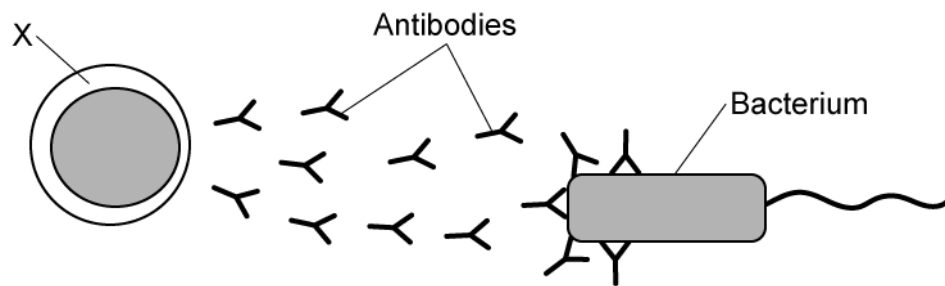
(1 mark)

(d) A blood clot in the coronary arteries is called coronary thrombosis.

List **three** risk factors that will increase the chance of developing coronary thrombosis.

(3 marks)

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 aid the body in fighting pathogens in a number of different ways.

State **one** way in which they achieve this.

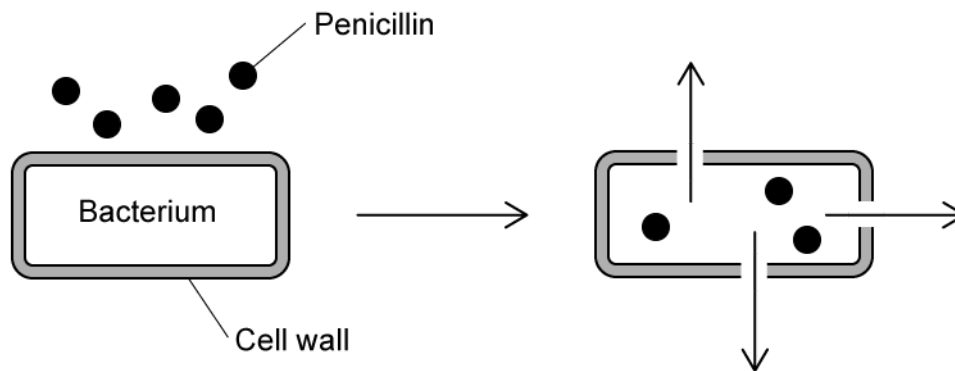
(1 mark)

(d) 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) One mark is available for clarity of communication throughout this question.

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.

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(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.

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(4 marks)

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

Outline the development of AIDS from an HIV infection.

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(5 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) 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)

- (d)** Stopping smoking has shown to be associated with reducing the incidence of coronary thrombosis.

State one other change of lifestyle that may reduce the incidence of coronary thrombosis.

(1 mark)

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

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(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.

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(2 marks)

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

Describe how this occurs.

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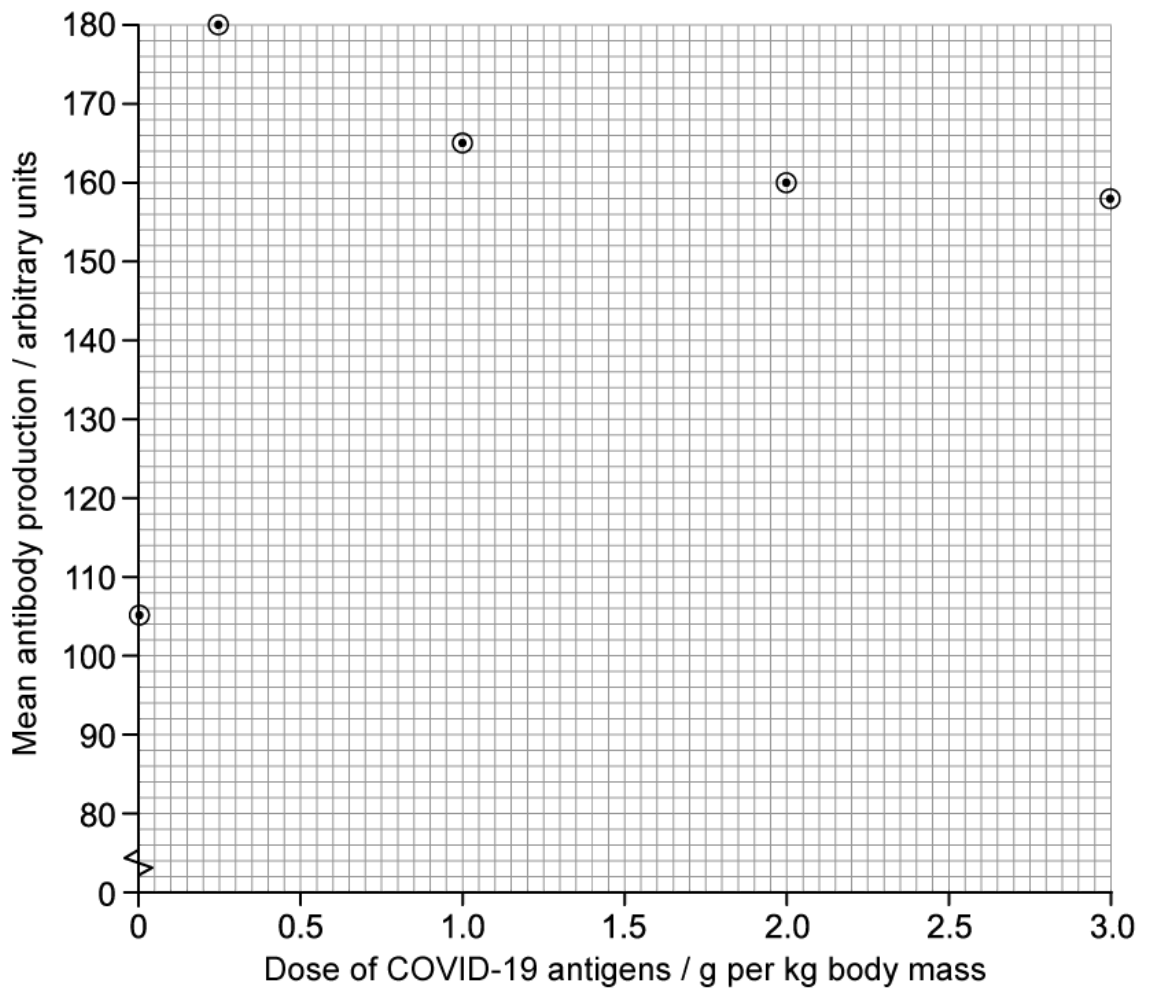
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(4 marks)

(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 <i>E.coli</i> resistant to tetracycline
Chickens	26
Chicken farmers	9
Turkeys	83
Turkey farmers	56

Suggest a hypothesis the farmers were testing in this investigation.

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(1 mark)

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

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(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.

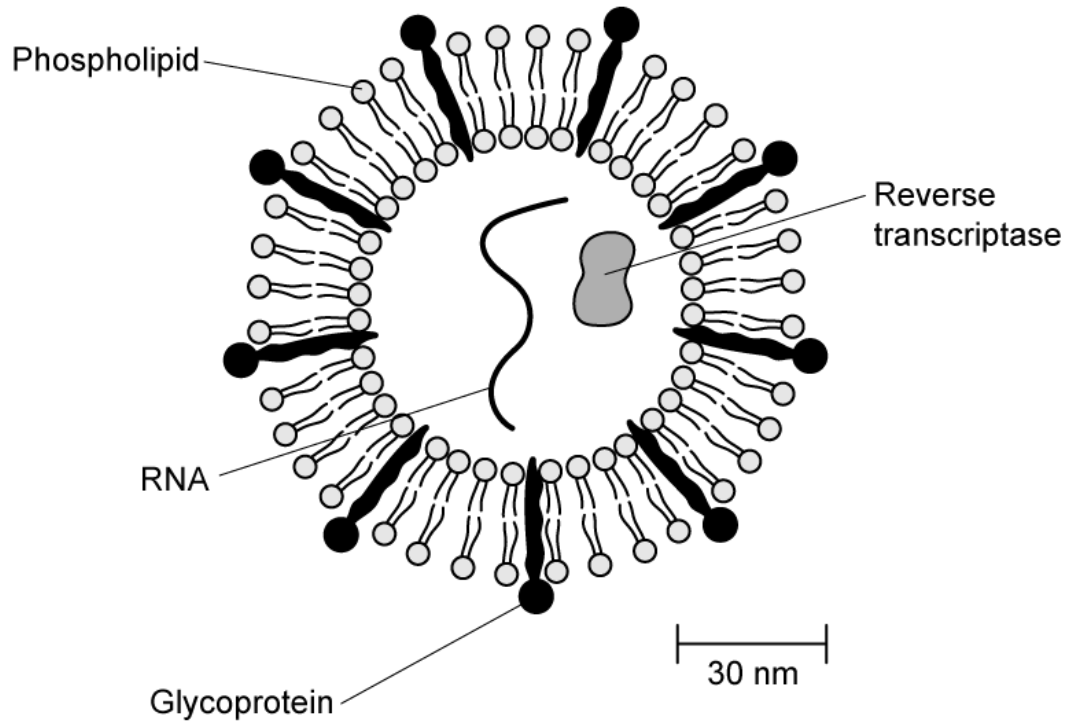
(2 marks)

- (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.

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(2 marks)

(b) HIV is described as a retrovirus.

Describe what is meant by the term retrovirus.

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

Howard Florey and Ernst Chain carried out experiments on mice and humans in the 1930s to test the effectiveness of penicillin.

Describe Florey and Chain's experimental method for testing penicillin on mice.

(5 marks)

(b) Florey and Chain's experiments involved some risks.

Outline the risks involved in their experiments.

(3 marks)

(c) Compare and contrast current drug testing protocols with Florey and Chain's experiments.

(7 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)

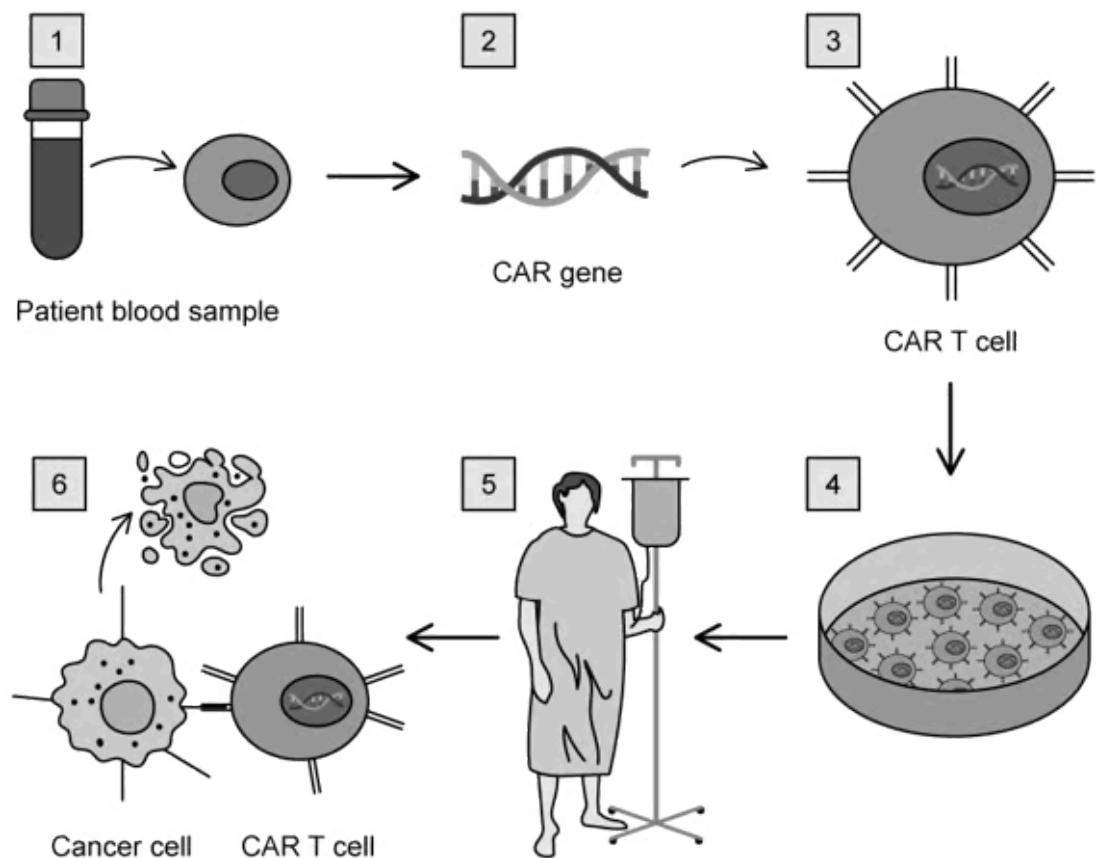
- (c)** There are a variety of ways to treat lupus. One form of treatment involves administering immunosuppressive drugs which prevents the activation of lymphocytes.

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)

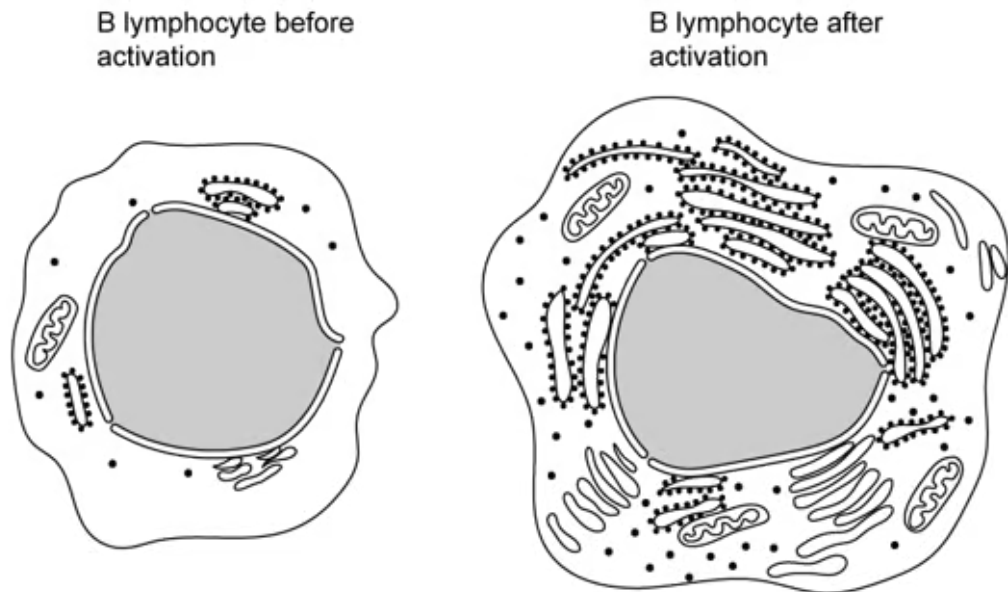
- (c) Traditional forms of cancer treatment include chemotherapy during which toxic chemicals are inserted into the blood stream of a patient. These chemicals will circulate through the body and kill any fast-dividing cells, which often leads to uncomfortable side effects such as hair loss, nausea and 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.

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(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.

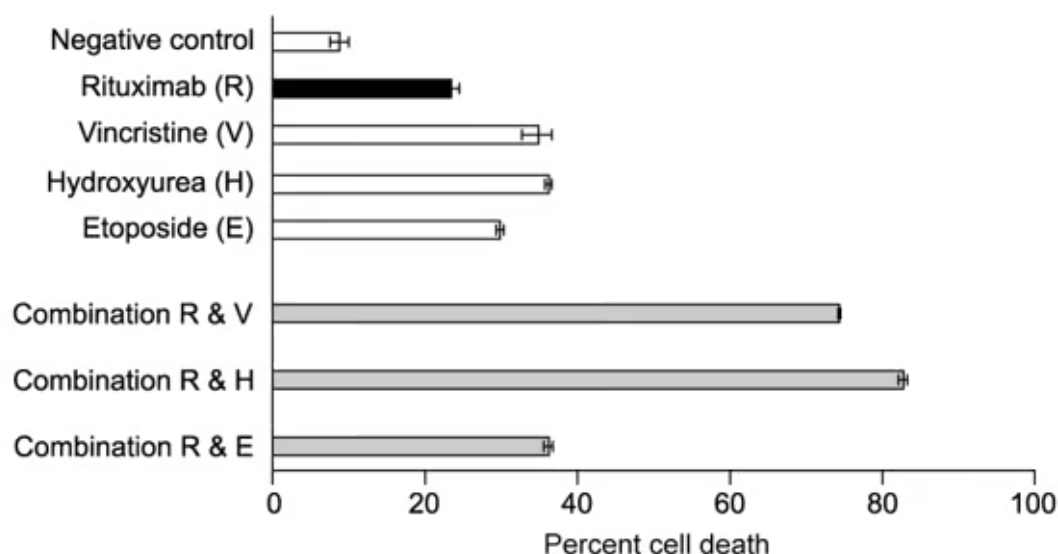
Based on your knowledge of the immune system, explain why patients would need regular infusions with rituximab.

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

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)