

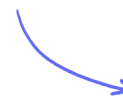
Structured Questions: Paper 2

# 11.1 Antibody Production & Vaccination

11.1.1 Antigens / 11.1.2 Specific Immune Response / 11.1.3 Antibodies, Vaccines & Immunity / 11.1.4 Smallpox Vaccine & Eradication / 11.1.5 Zoonosis / 11.1.6 Histamines / 11.1.7 Monoclonal Antibodies / 11.1.8 Skills: Analysing Epidemiological Data

Easy (5 questions)	/49
Medium (5 questions)	/46
Hard (5 questions)	/68
<b>Total Marks</b>	<b>/163</b>

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# Easy Questions

1 (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	

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**(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?

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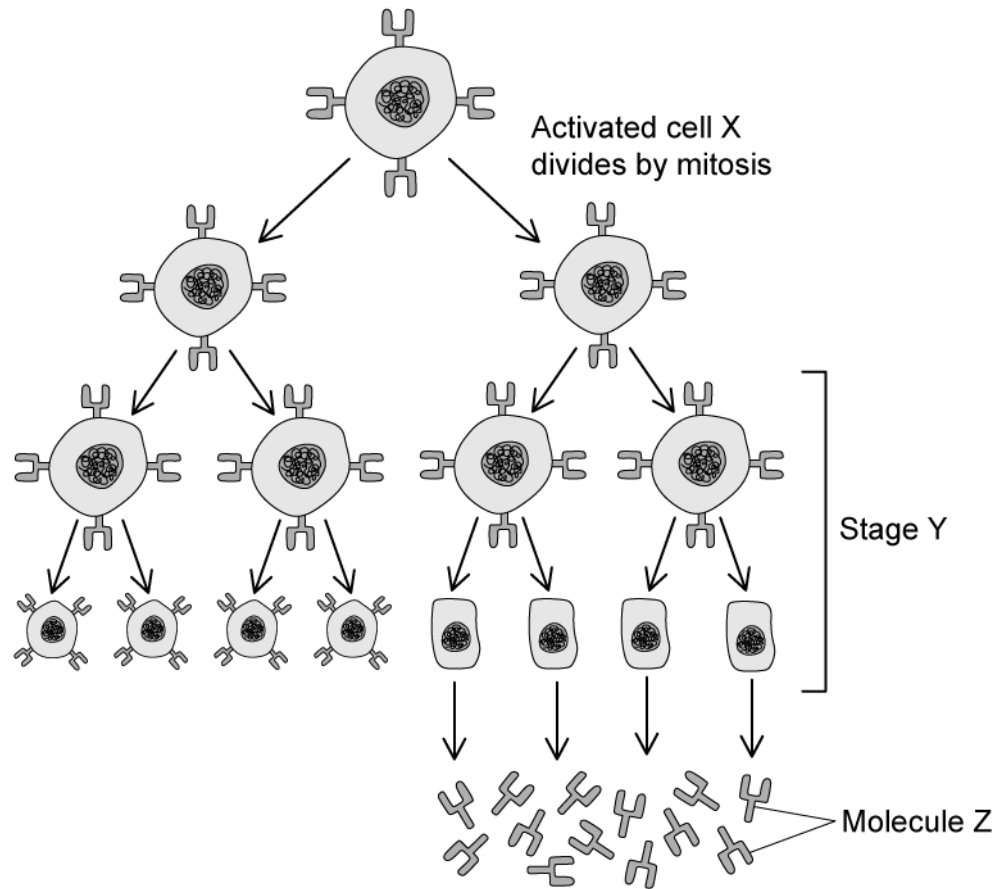
**(1 mark)**

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

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**(1 mark)**

2 (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]

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**(2 marks)**

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

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**(2 marks)**

(c) Give two ways in which a primary immune response is different to a secondary immune response.

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(2 marks)

(d) A secondary immune response relies on the presence of two key components within the blood of an individual.

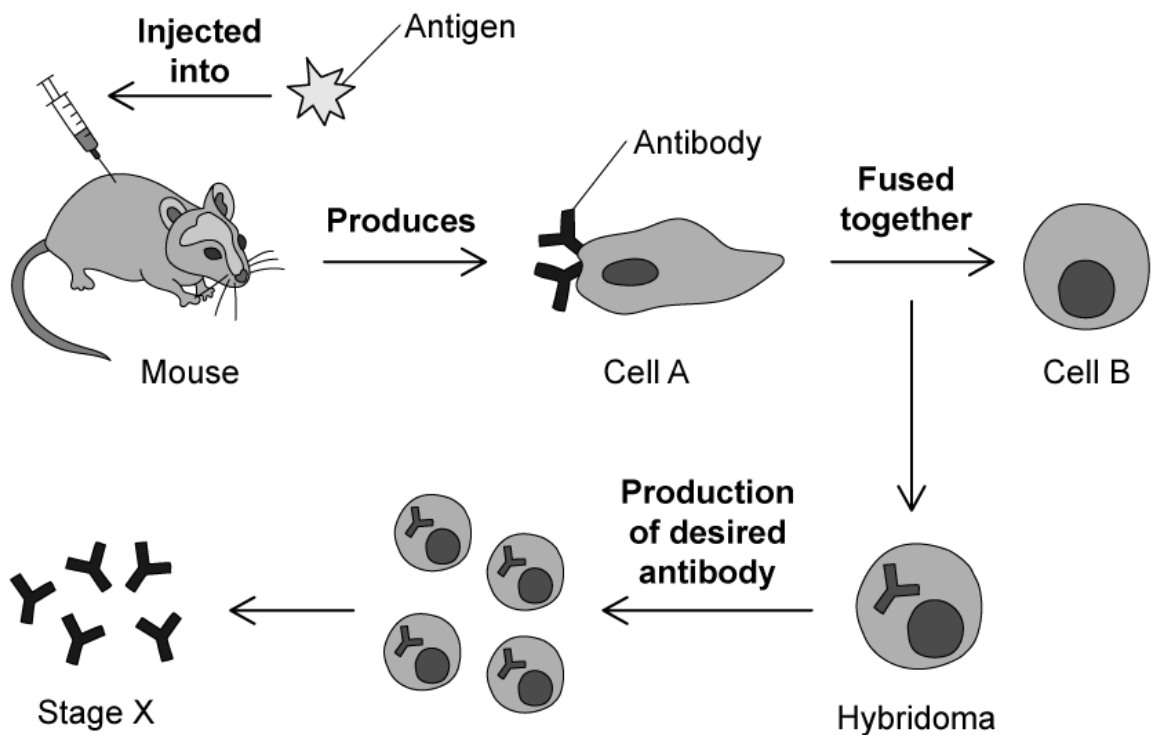
Name these components.

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(2 marks)

(e) Monoclonal antibodies are artificially produced antibodies which have multiple applications in science and medicine. The process of producing monoclonal antibodies can be seen below.



(i)

Which cell from cell **A** and cell **B**, represents the tumour cell used to give the hybridoma cell immortality.

[1]

(ii) Give one use of the monoclonal antibodies isolated in stage **X**.

[1]

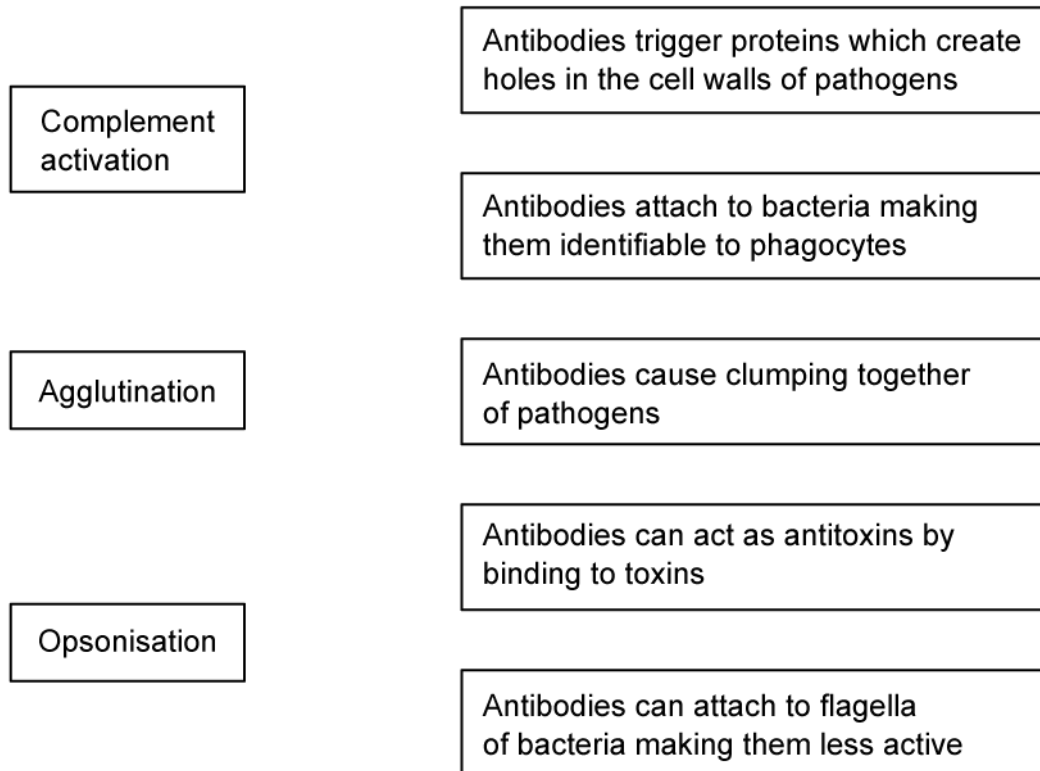
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**(2 marks)**

**3 (a)** Antibodies are produced to destroy pathogens that have invaded the body.

Some of the mechanisms for the destruction of pathogens are detailed below.



Match up the labels to the correct descriptions.

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**(3 marks)**

**(b)** 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]

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(2 marks)

(c) 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]

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(3 marks)

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

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(3 marks)

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

(i) Define the term pathogen.

[1]

(ii) Identify the type of pathogen which caused the development of smallpox.

[1]

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**(2 marks)**

**(b)** Prior to the development of Jenner's smallpox vaccination, doctors in the 1700's used a method which involved scratching smallpox material, into the arms of patients to trigger mild symptoms.

State the name of this method used by doctors.

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**(1 mark)**

**(c)** 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	

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**(3 marks)**

**(d)** 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.

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**(2 marks)**

5 (a) Describe the changes in blood antibody concentration after initial and secondary infection from one pathogen.

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**(4 marks)**

(b) Allergens such as pollen trigger the release of histamines into the blood, which lead to the development of symptoms which are characteristic of an allergic reaction.

List the symptoms which may result from histamine release in the blood.

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**(4 marks)**

(c) Describe how the study of epidemiology allows a greater understanding of diseases globally.

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(7 marks)

# Medium Questions

1 (a) Define the term 'antigen'.

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**(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	<b>1</b>
AB	Types A and B	<b>2</b>
O	None	O

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

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**(2 marks)**

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

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(2 marks)

- (d) Antibodies are proteins that bind to specific non-self antigens. Individuals with type B blood have antibodies that will bind to type A antigens.

Suggest which type(s) of antibodies would be found in the blood of an individual with type **O** blood and in the blood of an individual with type **AB** blood.

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(2 marks)

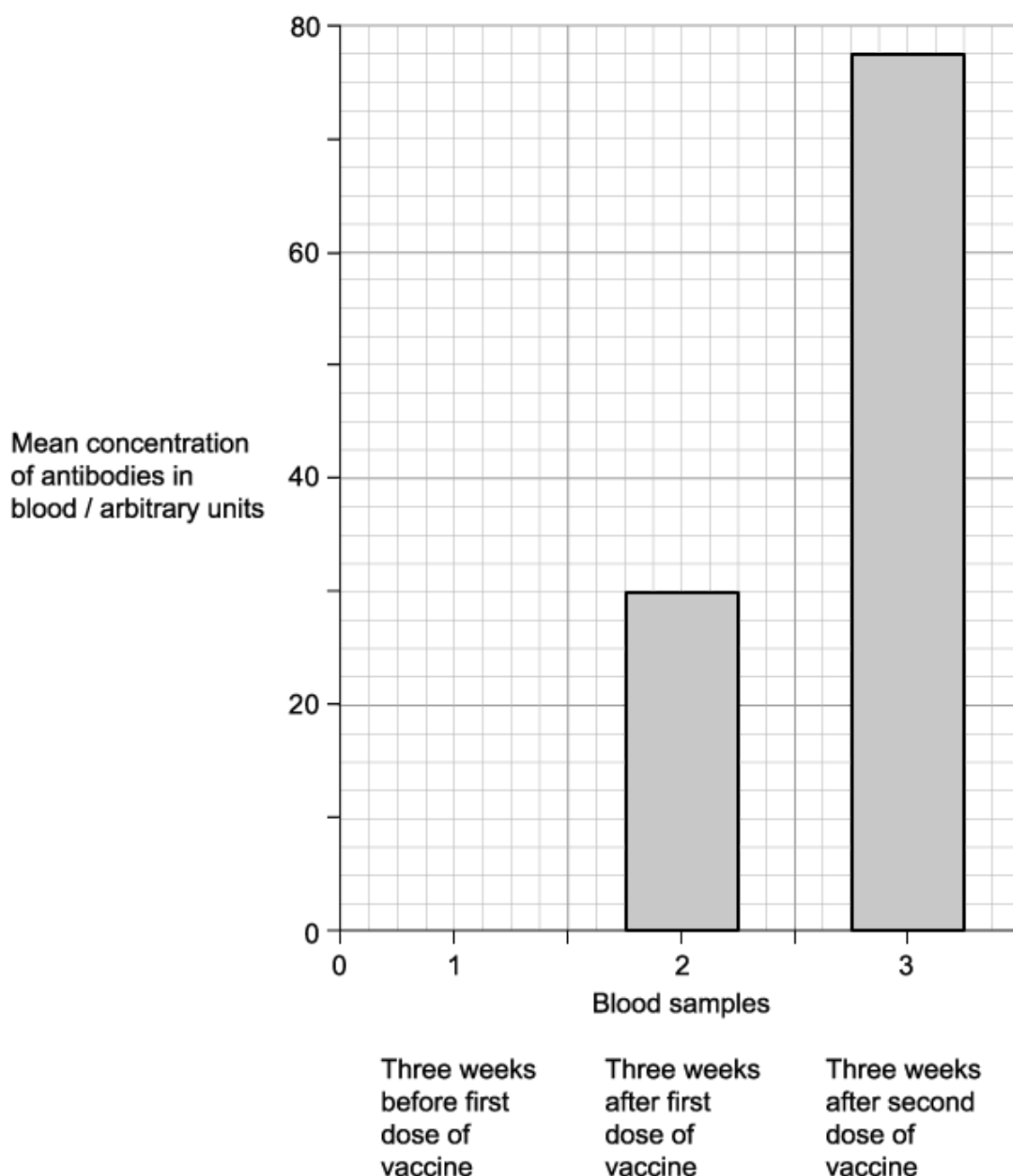
**2 (a)** A medical researcher vaccinated a group of adult patients against human papillomavirus (HPV). He gave each patient two doses of vaccine five months apart. The researcher tested three samples of blood from each of the patients for antibodies against HPV.

**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.

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**(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.

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**(2 marks)**

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

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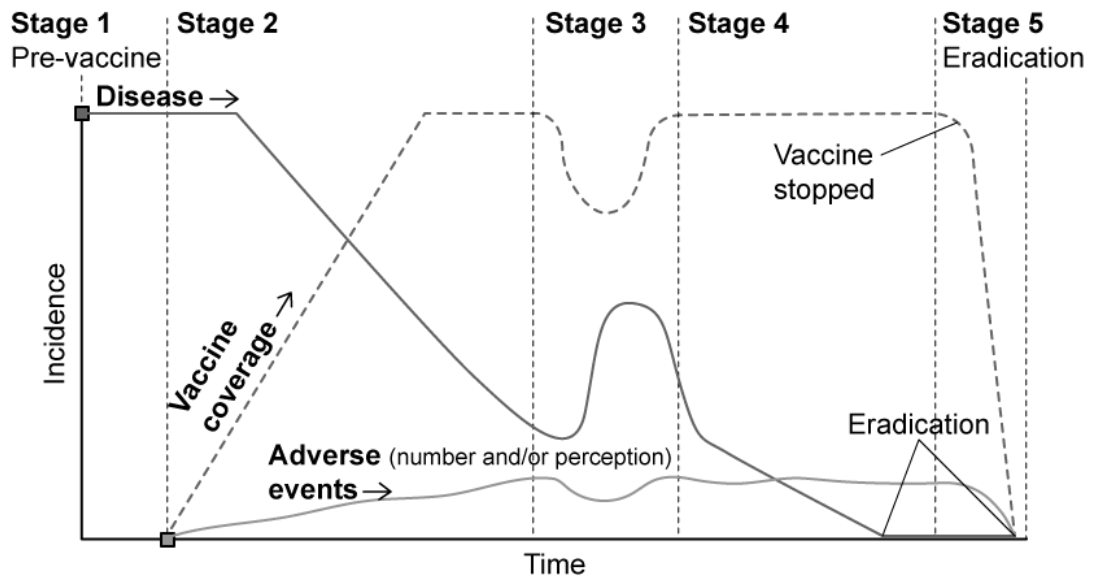
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**(4 marks)**

3 (a) The graph below shows the events that take place during the progression of a vaccination programme.



Suggest what the 'adverse events' labelled in the graph might be.

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(1 mark)

(b) Reaching the end of stage 5 in the graph in part a) is rare, and has so far only been accomplished for smallpox.

Outline why it has not been possible to complete stage 5 for any diseases other than smallpox.

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(4 marks)



- (c) The smallpox vaccine was developed by Edward Jenner after he inoculated 9-year-old James Phipps with cowpox virus.

Explain how James Phipps developed plasma cells in response to the cowpox inoculation.

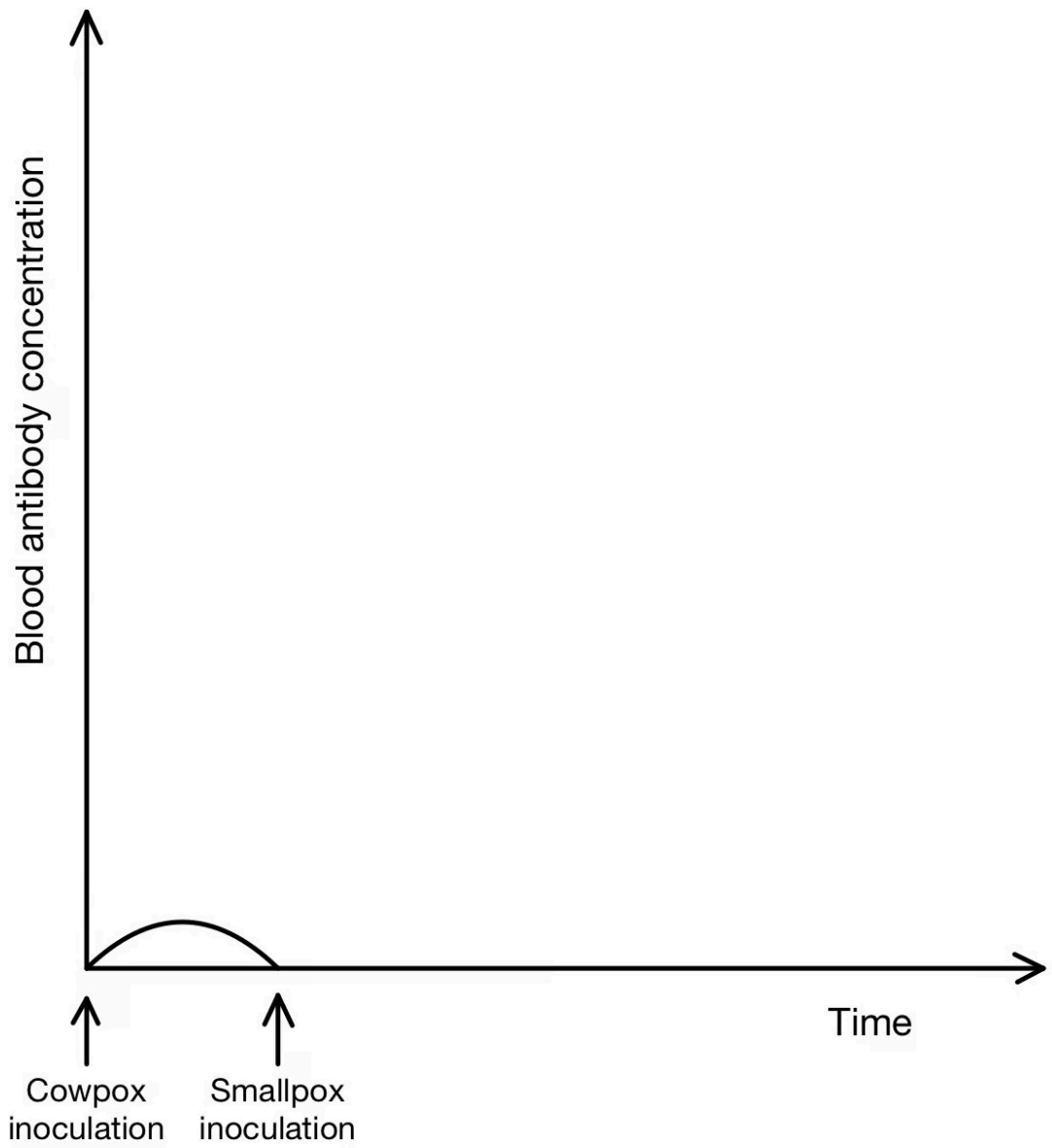
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**(2 marks)**

- (d) The graph below shows James Phipps' antibody production in response to inoculation with cowpox.

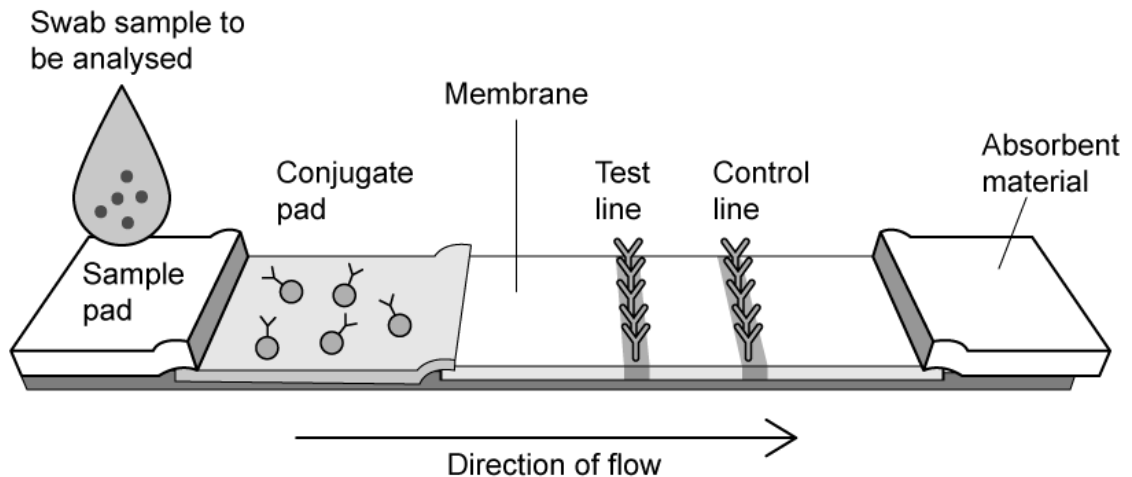
Sketch a curve on the graph to show his antibody production in response to later inoculation with smallpox.



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(1 mark)

- 4 (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.

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**(2 marks)**

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

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**(2 marks)**

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

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**(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.

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(2 marks)

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

Explain the role of histamines in an allergic response.

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**(4 marks)**

**(b)** Describe how tumour cells can be used in the production of monoclonal antibodies.

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**(5 marks)**

**(c)** Explain how antibodies combat infection.

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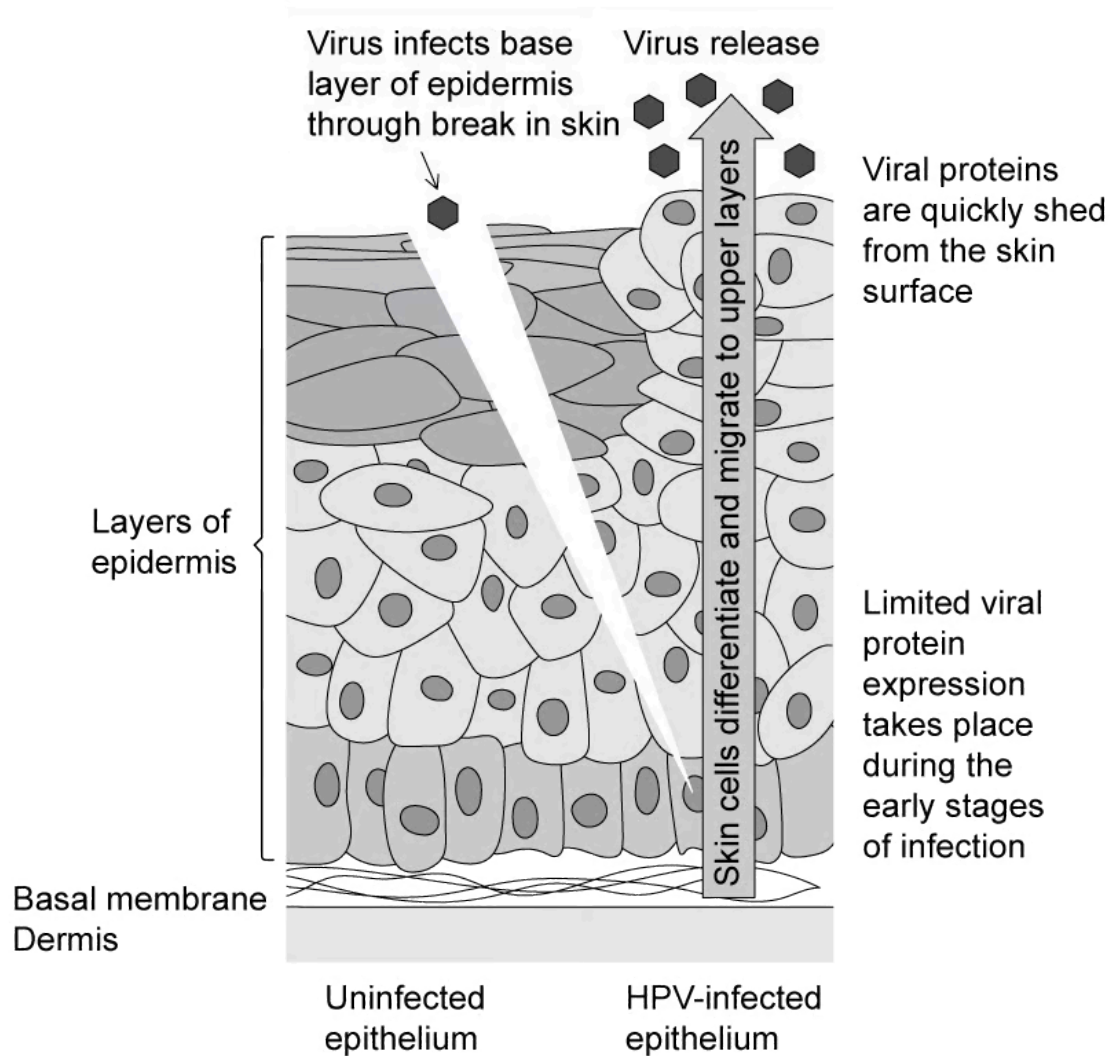
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**(6 marks)**

# Hard Questions

1 (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.

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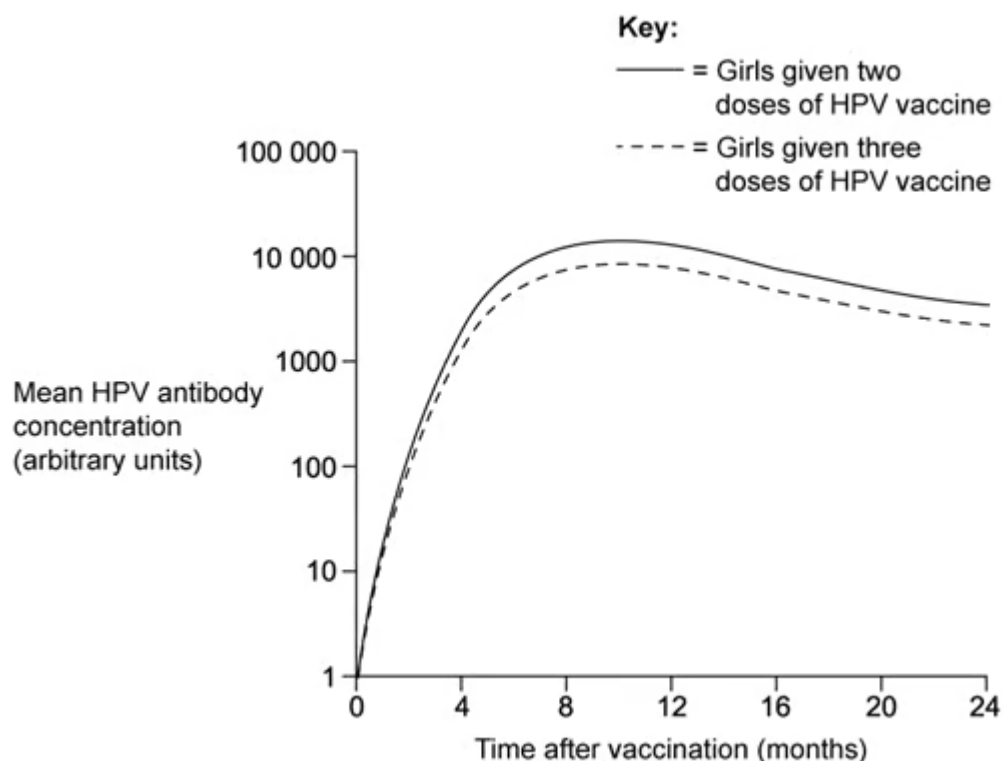
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(3 marks)

- (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.

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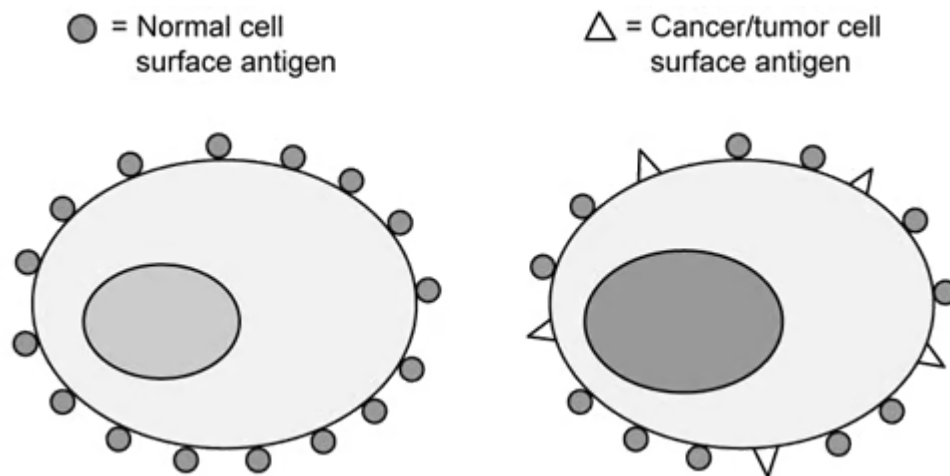
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**(3 marks)**

- (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.

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**(4 marks)**

**(d)** It is hoped that one day, cancer vaccinations may exist which prevent cancer rather than for treatment of cancer. Trials to test these new vaccines will be put through a rigorous development procedure as follows:

- I. Research and development stage using bioinformatics
- II. Non-clinical trials in the laboratory (testing efficacy and toxicity)
- III. Whole organism testing on animals (testing efficacy, toxicity and dosage)
- IV. Clinical trials on adult human volunteers

Compare and contrast these modern methods of vaccine development with those used by Edward Jenner in the development of the smallpox vaccine.

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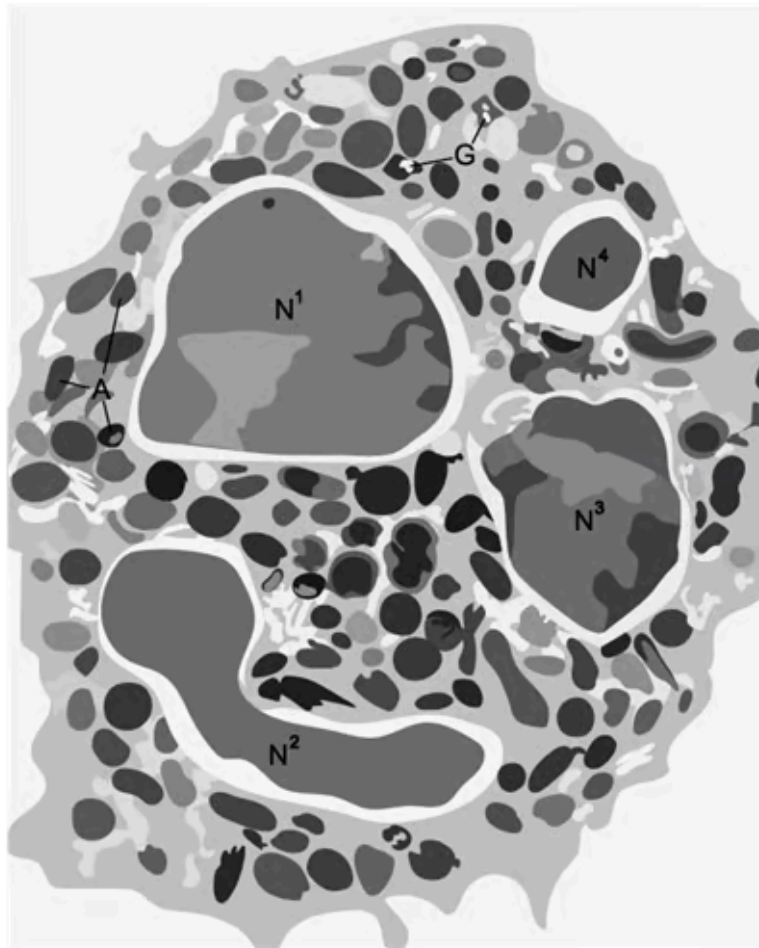
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**(4 marks)**

- (e)** 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.

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**(2 marks)**

2 (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.

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**(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.

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**(5 marks)**

- (c)** Antigens associated with allergens such as pollen or food substances can trigger both specific and non-specific immune processes.

One such process is the release of histamines in response to activation of B-lymphocytes.

Justify, with a reason, which part of this process constitutes a specific immune response.

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**(2 marks)**

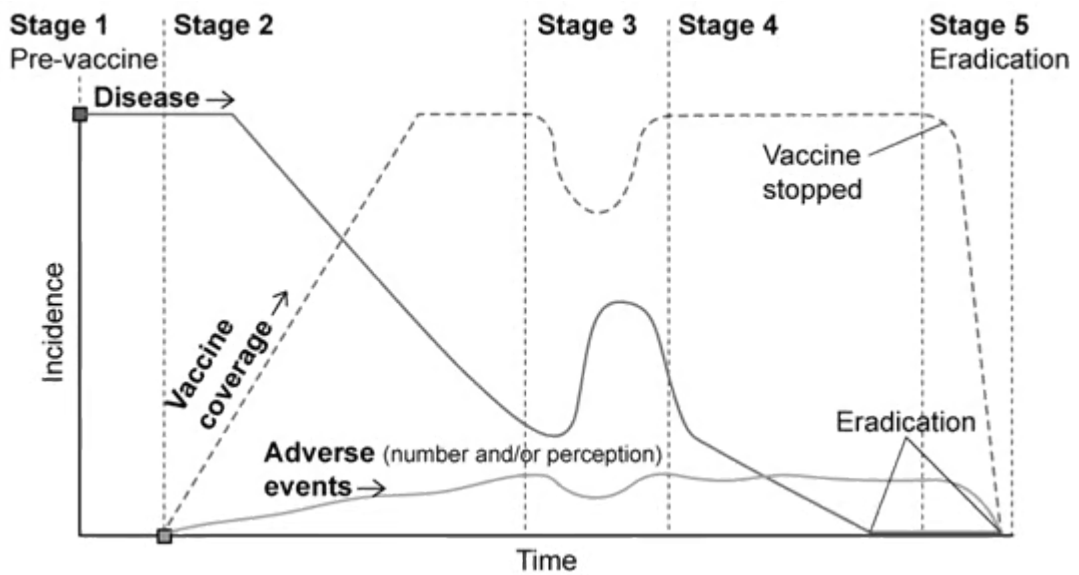
- (d)** Explain how the histamines released during an allergic reaction may assist phagocytes in their role.

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**(2 marks)**

3 (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.

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(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.

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(3 marks)

(c) 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.

Use the information in the table and your own knowledge to explain why.

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**(3 marks)**

(d) 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.

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

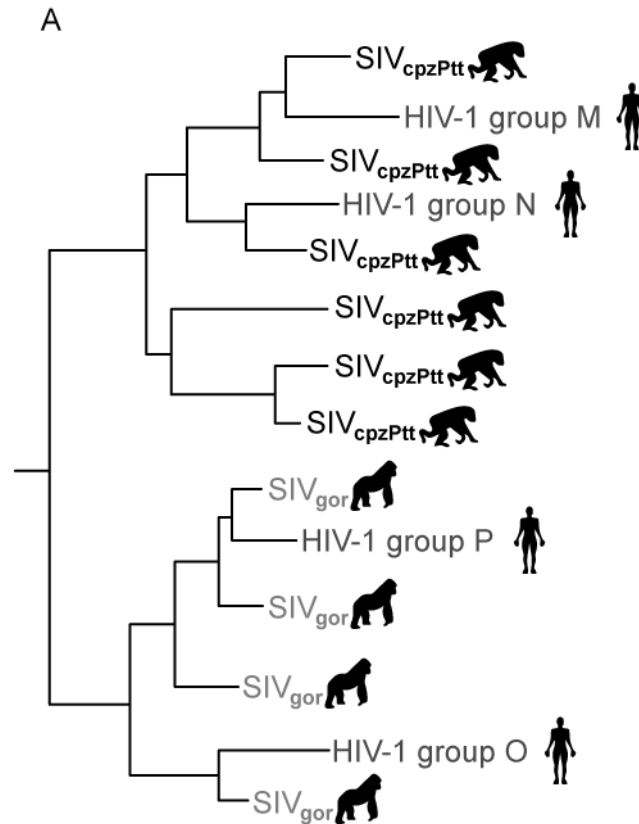
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**(2 marks)**

4 (a) The image shows the evolutionary links between the simian immunodeficiency virus (SIV) and the human immunodeficiency 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.

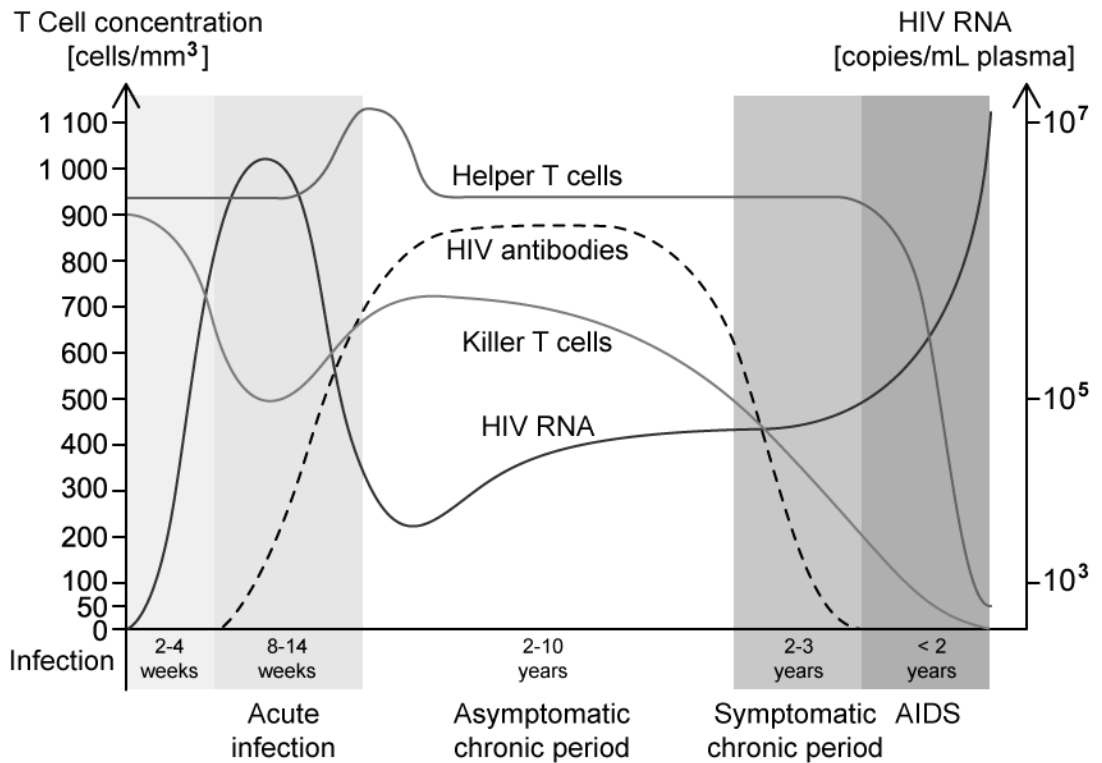
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(3 marks)

(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.

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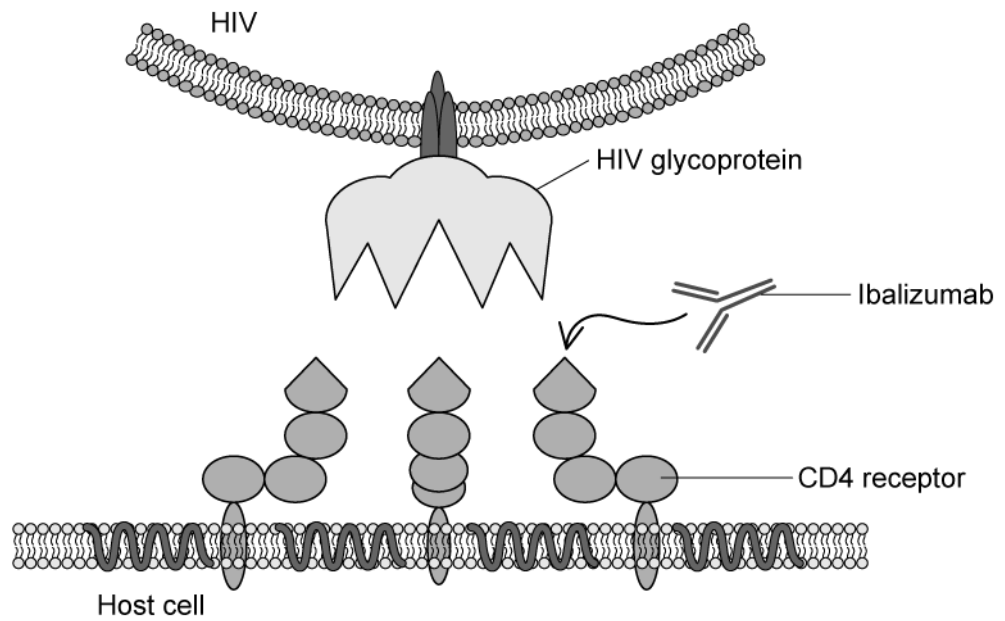
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**(4 marks)**

- (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

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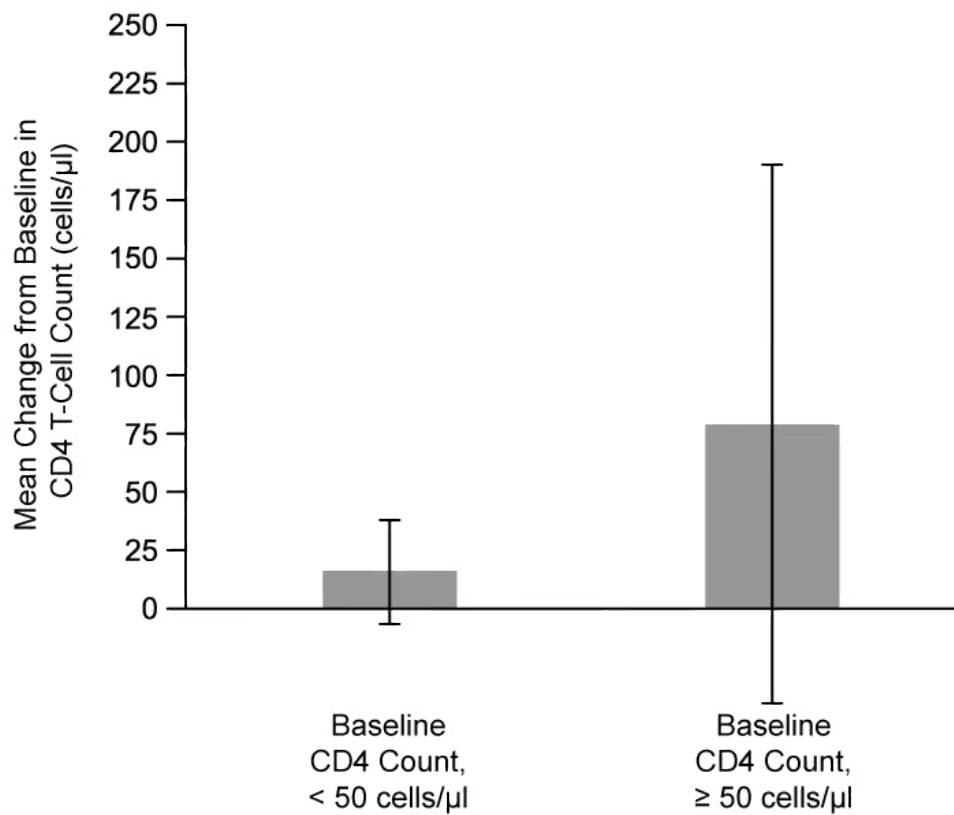
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**(3 marks)**

- (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.

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**(3 marks)**

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

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.

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**(4 marks)**

**(b)** Outline the process which occurs in a pregnancy test to give a positive test result.

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**(5 marks)**

**(c)** Discuss the benefits and risks associated with vaccination programmes.

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**(6 marks)**