

1(a). A vaccine against polio was introduced in 1956.

- i. Suggest the contents of the original anti-polio vaccine.

-----**[1]**

- ii. B-lymphocytes and T-lymphocytes are involved in the immune response.

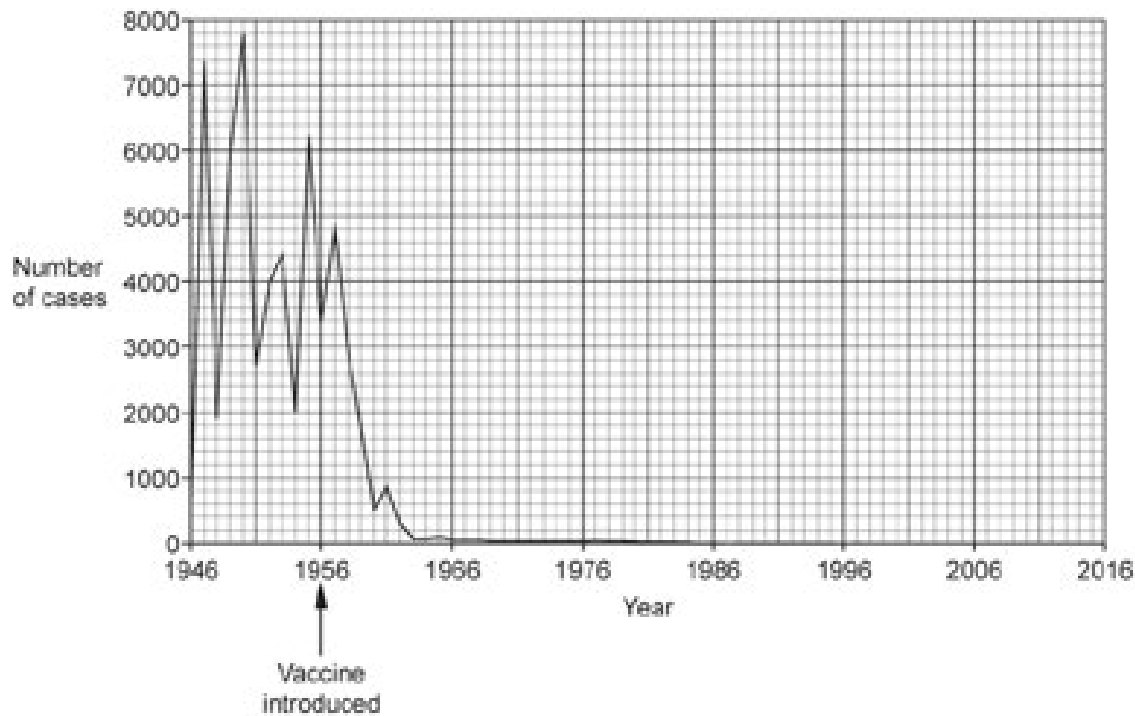
Describe the role of T-lymphocytes in the development of immunity to a virus such as polio.

-----**[4]**

(b). Vaccination can protect an individual from infectious disease.

Polio is a viral disease that usually affects children and can have lifelong effects.

The graph shows the number of cases of polio in England and Wales between 1946 and 2016.



- i. Calculate the percentage decrease in cases between 1956 and 1960.

% decrease = **[2]**

- ii. A student wants to use the calculation in part (i) to support a conclusion about the effectiveness of the polio vaccination. Another student argues that it would be better to have used 1957 as a starting year for the calculation.

Suggest **two** reasons why 1957 might have been a better starting year for the calculation.

1

2

[2]

- iii. There were cases of polio in England and Wales in the 1980s.

The scale used on the graph is not sensitive enough to show changes in the number of cases during the 1980s.

Suggest **one** way in which the y-axis scale could be changed in order that changes in the 1950s and 1980s were both visible.

[1]

- iv. Between 90% and 95% of UK children are currently fully vaccinated against polio.

In 2022 some particles of polio virus were detected in sewage in London. As a result, an extra dose of the polio vaccine was offered to children in London. The vaccine was not offered to children across the whole country.

Suggest why the extra vaccine was offered to children in London only.

[2]

2(a). Zombie-ant fungus is a pathogen that causes a disease in ants.

The figure shows an ant infected by the zombie-ant fungus.



This fungus affects the behaviour of an ant in these ways:

- An infected ant will climb to a high point in a tree, bite into a branch or leaf and then remain there until it dies.
- The fungus feeds on the dead ant and produces a stalk from the ant's head.
- The stalk then breaks open, releasing fungal spores.

- i. Suggest **two** ways in which the ant's behaviour helps to increase the spread of the zombie-ant fungus.

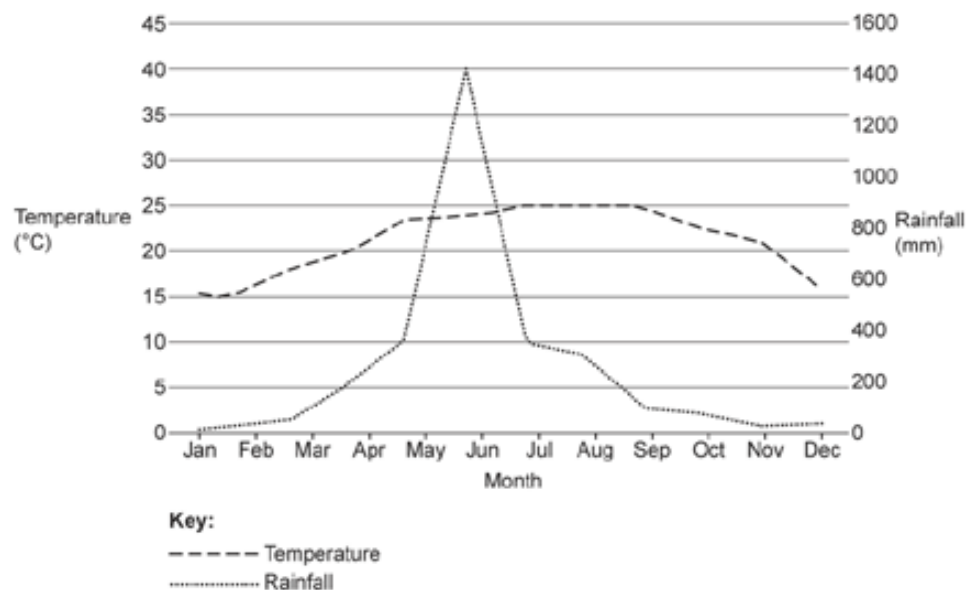
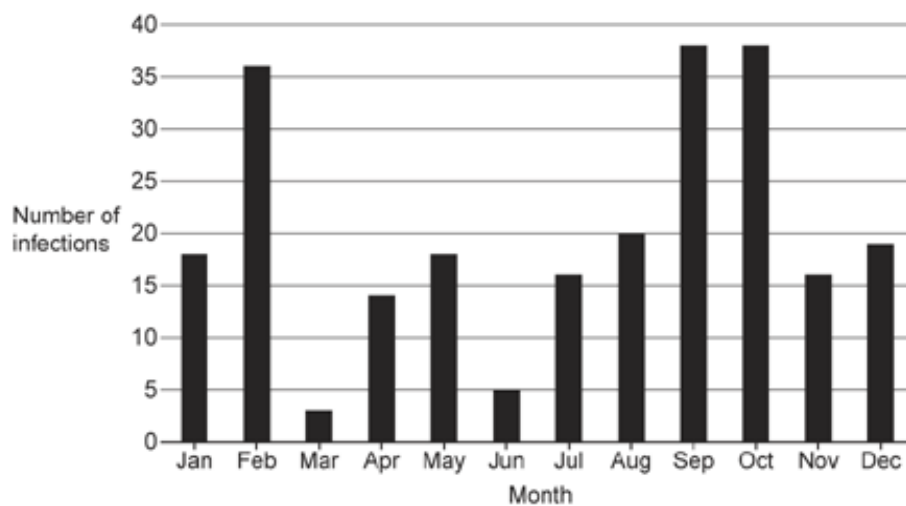
1 _____

2 _____

[2]

- ii. Scientists carried out a study in 2017 in Taiwan to see if various climatic factors affected the numbers of zombie-ant fungus infections.

The two figures show the findings of this study.



'Zombie-ant fungus infections increase after heavy rainfall but are not affected by temperature.'

[illegible]

[6]

(b). Complete the table with the type of pathogen that causes the communicable disease.

Communicable Disease	Type of Pathogen
Influenza	
Malaria	
Black sigatoka in bananas	

[3]

3. Plants can be cloned and propagated in horticulture and agriculture.

Potato plants can be naturally cloned from tubers.

Many diseases can infect potato plants.

State **one** disease that can infect potato plants **and** state the type of pathogen that causes the disease.

Disease

Type of pathogen

----- [2]

4(a). Haemoglobin is a conjugated protein with quaternary structure.

The bacterium, *Pseudomonas aeruginosa*, does not have haemoglobin.

P. aeruginosa is found in natural water sources.

Infection by *P. aeruginosa* can cause the disease, hospital-acquired pneumonia (HAP).

One hospital assessed the frequency of people admitted to the intensive care unit (ICU) with HAP in 2013.

The results were:

- 346 people were admitted to the ICU and HAP was diagnosed in 25.4% of these people.
- 14.6% of people diagnosed with HAP died due to infection by *P. aeruginosa*.
- This number was 35% higher than in 2012.

Calculate the **number** of people who died due to infection by *P. aeruginosa* in **2012**.

Give your answer to the **nearest whole number**.

Number of people = [2]

(b). The bacterium *Pseudomonas aeruginosa* can cause the disease, hospital-acquired pneumonia (HAP). The treatment for people in hospitals that have HAP due to *P. aeruginosa* is to give antibiotics. Some populations of *P. aeruginosa* have become resistant to specific antibiotics.

Suggest **and** explain the potential implications of antibiotic resistance for hospitals.

----- [3]

(c). Scientists have suggested that personalised medicine may be used to help with the problem of antibiotic resistance.

State what is meant by personalised medicine.

[1]

5. Phagocytes engulf pathogens during phagocytosis and digest them using enzymes.

These enzymes can be found in lysosomes.

Explain how the enzymes inside lysosomes come into contact with pathogens that have been engulfed.

[2]

6. Ring rot is an infection that can kill potato plants.

Which kingdom does the organism that causes ring rot belong to?

- A** Fungi
- B** Prokaryotae
- C** Protocista
- D** Viruses

Your answer ☐ **[1]**

7. What is an example of a disease transmitted by a vector?

- A** Hepatitis C from sharing needles
- B** Herpes simplex virus from sharing lipstick
- C** HIV from unprotected sex
- D** Malaria from mosquitoes

Your answer ☐ **[1]**

8. Plant defences can be described as chemical or physical.

Which of the following results in a **physical** defence against a pathogen?

- A Plants produce hormones, which alert nearby plants of their own infection
- B Plants synthesise callose, which they use to block plasmodesmata
- C Plants synthesise enzymes called chitinases to break down fungal cell walls
- D Plants synthesise proteins called defensins, which disrupt metabolism to cause cell death of the pathogen

Your answer

☐

[1]

9. Which statement describes a problem that has resulted from the increased use of antibiotics?

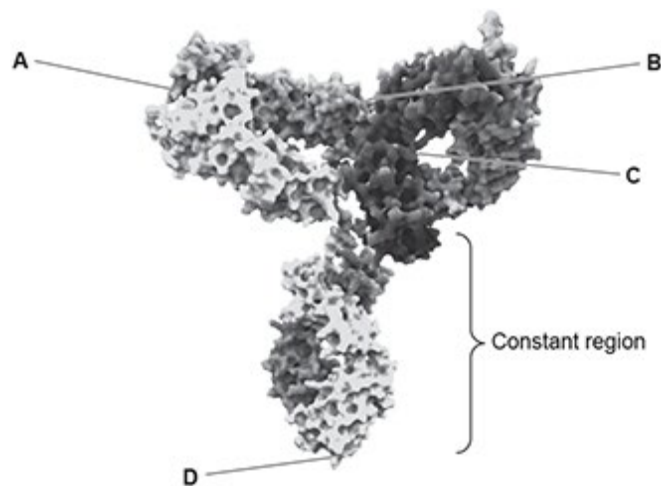
- A Penicillin can no longer be used to treat infections.
- B Rates of MRSA infection have increased.
- C Some bacteria and fungi have evolved resistance to antibiotics.
- D Viral infections can no longer be treated with antibiotics.

Your answer

☐

[1]

10. The diagram shows a computer model of the structure of an antibody.



Which part of the antibody, **A**, **B**, **C** or **D**, is an antigen-binding site?

Your answer

☐

[1]

11(a). Animals are protected from infectious diseases by their immune system.

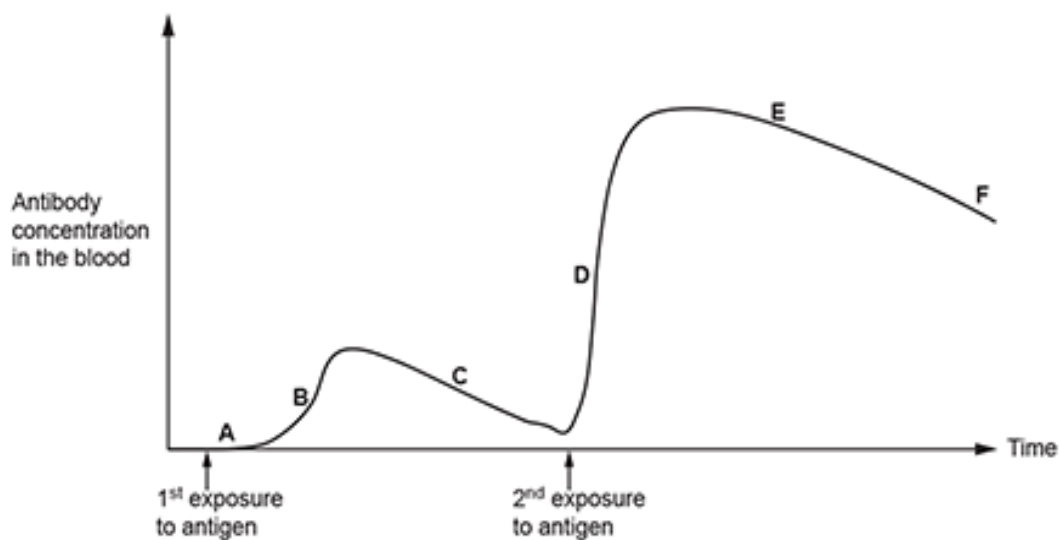
Influenza is a viral disease that is common in winter months. It is transmitted when an uninfected person inhales droplets of moisture that an infected person has exhaled, often when coughing or sneezing.

Explain how mucous membranes make it more difficult for the influenza virus to enter the body.

[2]

(b). Antigens on the surface of pathogens can provoke an immune response in a patient.

The figure below shows the changes in antibody concentration in the blood of a patient.



Different events during these immune responses have been represented as areas on the graph labelled with letters, **A** to **F**.

Complete the table with a letter or letters to indicate where on the graph the event is represented.

Event	Letter or letters
Antigen presentation	
Clonal expansion	
Clonal selection	
High T-helper cell activity	
Highest number of memory cells	

[5]

(c). Fragments of antibodies, known as Fab fragments, have a number of uses.

- i. Snakebites can be treated using Fab fragments.

Antibodies specific to the snake venom are produced using donor animals, usually sheep. These antibodies are collected from the animal's blood and then digested to produce Fab fragments. The patient can be injected with these fragments after being bitten by a snake.

Name the type of immunity this treatment gives the patient.

-----[1]

- ii. The figure below shows the structure of a Fab fragment.



Identify **two** similarities and **one** difference in structure between a Fab fragment and a whole antibody.

Similarity 1 _____

Similarity 2 _____

Difference _____

-----[3]

(d). Infectious disease caused by pathogenic bacteria can be treated using antibiotics. The first antibiotics became widely available in the middle of the 20th Century.

Explain why many varieties of pathogenic bacteria are now resistant to a range of antibiotics.

-----[3]

(e). Plants and microorganisms have traditionally been used as sources of new medicines.

Synthetic biology could play a major role in the development of new medicines.

Outline how synthetic biology can be used in the provision of new medicines.

-----[2]

12(a). Measles, Mumps and Rubella are communicable diseases. They can be prevented by the use of the MMR vaccine which is administered to children.

The table below shows some data on the number of children given the MMR vaccine and the incidence of measles between 2012 and 2014.

MMR vaccinations		
Date	Country	Number of vaccinations administered
2013 (Oct to Dec)	England	171,855
2014 (Jan to March)	England	162,193
Confirmed cases of measles		
Date	Country	Number of confirmed cases
2012	England and Wales	2,032
2013	England	1,414
2014	England	102

- i. Using the data provided in the table, calculate the percentage decrease in the number of vaccinations administered in England between 2013 and 2014.

Give your answer to **2** significant figures.

Percentage decrease = **[2]**

- ii. Student **A** studied the data in the table and made the following statement:

‘The MMR vaccination programme is not working because although the number of children vaccinated has reduced, measles incidence has also reduced.’

In response, student **B** stated:

‘You cannot tell this from the data provided here.’

With reference to the data in the table, discuss whether student **B** is correct.

..... **[4]**

- iii. A student made the following statement about the influenza (flu) vaccination programme:

‘The flu vaccination programme involves giving the same flu vaccine to different age groups and to medically vulnerable people every year, as it is for the same disease.’

Discuss the accuracy of the student’s statement.

..... **[3]**

- iv. Explain how vaccination programmes can play a role in preventing epidemics.

[2]

(b). Rheumatoid arthritis is an autoimmune disease that causes pain in skeletal joints.

- i. Explain the meaning of the term **autoimmune disease**.

[1]

- ii. Collagen is a protein found in ligaments. Ligaments attach bone to bone and stabilise joints.

State the properties of collagen that make it suitable for this function.

[2]

- iii. Neutrophils are produced by stem cells.

State where in the body these stem cells are found.

[1]

- iv. A student wrote the following passage about the immune system:

‘T helper cells produce cell signalling molecules called perforins. These stimulate the activity of B cells which increase antibody production. Agglutinins cause pathogens with antigen-toxin complexes to clump together.’

Identify **two** errors in the statement and write a correction for each error.

1

2

[2]

13(a). The heart can be affected by a variety of disorders, some of which involve the immune system.

Fig. 1.1 shows the roles of three different types of antibody, labelled **R**, **S** and **T**.

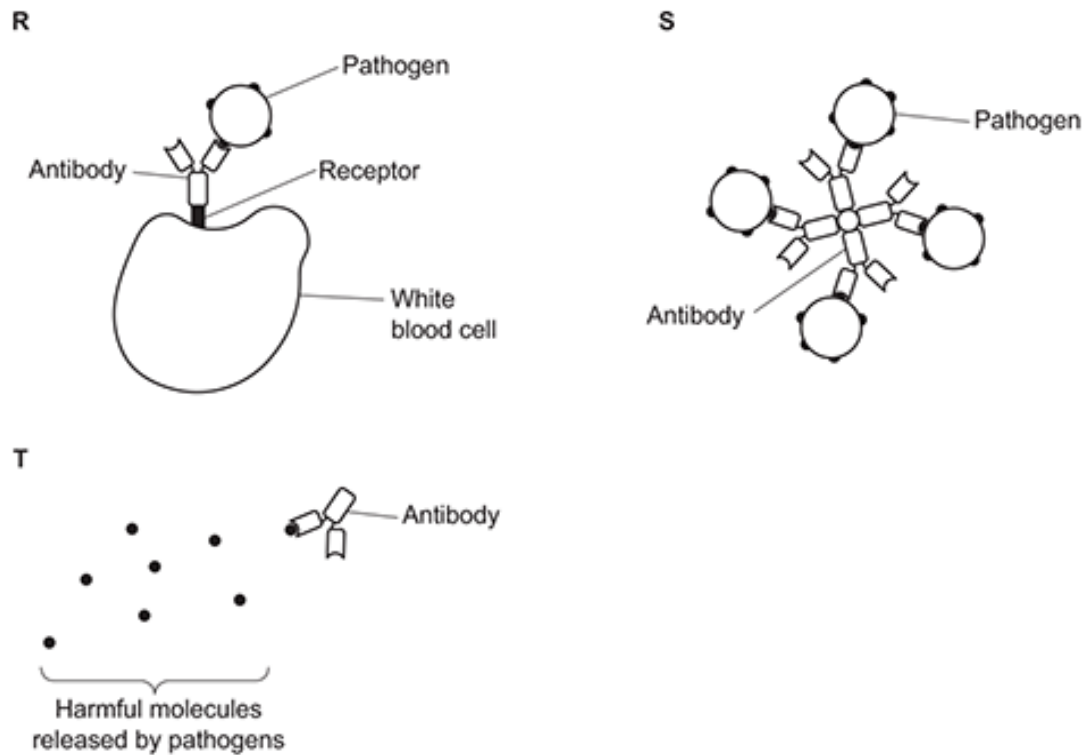


Fig. 1.1

State the names of the **three** different types of antibody shown in **Fig. 1.1**.

R

S

T

[3]

(b). A condition called rheumatic heart disease can occur when a person's antibodies attack antigens on their own heart cells.

State the name of the **type** of disease represented by rheumatic heart disease.

[1]

14(a). **Fig. 2.1** shows a light micrograph of a blood smear.

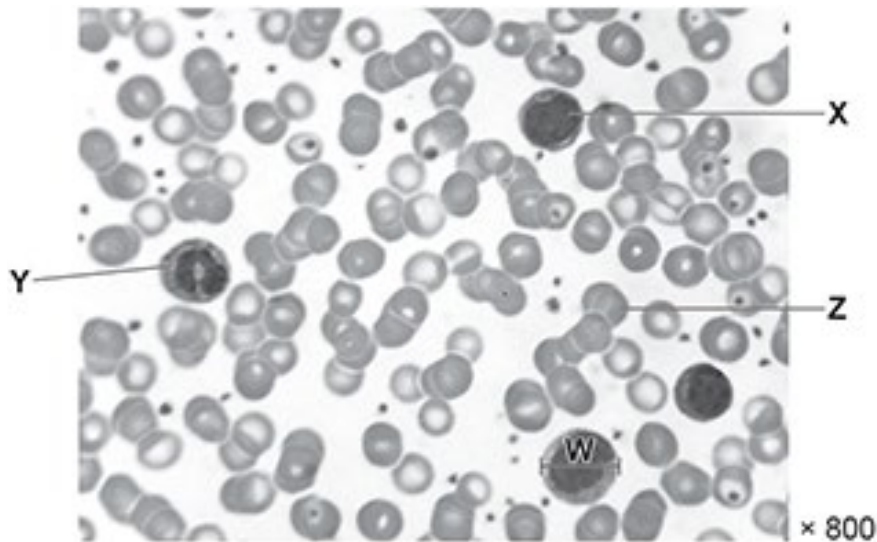


Fig. 2.1

- i. The cells labelled **X** and **Y** in **Fig. 2.1** are two different types of white blood cell.

Identify the types of white blood cell labelled **X** and **Y**.

X

Y

[2]

- ii. The blood cell labelled **Z** in **Fig. 2.1** contains a high concentration of haemoglobin.

Outline **two** other ways in which the blood cell labelled **Z** is adapted for its function.

[2]

- iii. The diameter of another blood cell is represented by the line **W** in **Fig. 2.1**.

The magnification used to produce **Fig. 2.1** was $\times 800$.

Calculate the actual diameter, **W**, of the blood cell.

Give your answer in μm .

Diameter = μm [2]

(b). Some white blood cells have a high concentration of lysosomes.

- i. State the role of lysosomes in white blood cells.

[1]

- ii. A scientist calculated two values for the lysosomes in a white blood cell:

- mean volume of a lysosome = $6.5 \times 10^{-14} \text{ cm}^3$
- mean number of H^+ ions per lysosome = $1.3 \times 10^{-21} \text{ mol}$

Use these values to calculate the mean H^+ ion concentration per lysosome in this white blood cell.

Give your answer in mol dm^{-3} .

Mean H^+ ion concentration = mol dm^{-3} [2]

- iii. The formula used to calculate pH is

$$\text{pH} = -\log [\text{H}^+]$$

where $[\text{H}^+]$ is H^+ ion concentration in mol dm^{-3} .

Use your answer from **part (ii)** to calculate the mean pH of the lysosomes in this white blood cell.

Give your answer to **2** significant figures.

pH = **[1]**

- iv. The scientist stained the lysosomes in a sample of living white blood cells.

The table shows the properties of five stains, **A** to **E**.

Stain	Properties
A	Suitable to stain alkaline components. Taken up by active cells.
B	Suitable to stain acidic components. Taken up by active cells.
C	Suitable to stain neutral components. Taken up by active cells.
D	Suitable to stain alkaline components. Can be used to stain fixed sections of tissue.
E	Suitable to stain acidic components. Can be used to stain fixed sections of tissue.

Select the most appropriate stain for the scientist to use, based on your answer from **part (iii)**.

..... **[1]**

15(a). Outline the roles of phagosomes and lysosomes in phagocytosis.

..... **[3]**

(b). **Fig. 4.1** shows a light micrograph of cells in the blood.

Cell **X** plays a role in the immune response.

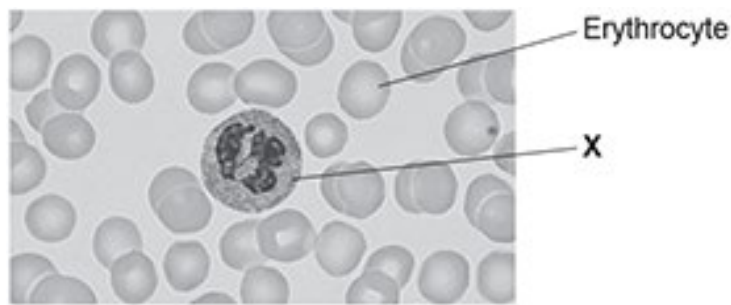


Fig. 4.1

- i. Name cell **X**.

..... **[1]**

- ii. The magnification of the microscope used to observe the cells in **Fig. 4.1** was $\times 950$.

Calculate the diameter of cell **X** in **Fig. 4.1**.

Give your answer in micrometres.

Diameter = μm **[2]**

- iii. Using **Fig. 4.1**, explain why blood is described as a tissue and not an organ.

..... **[1]**

(c). Every winter a large proportion of the population are given a vaccine against the disease influenza.

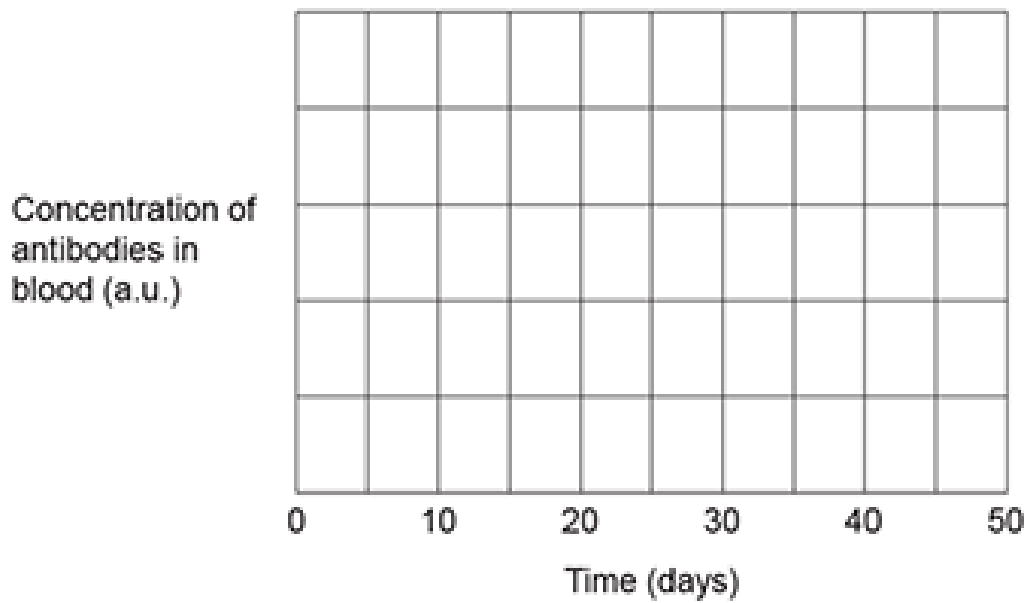
- i. Identify the type of immunity given by an influenza vaccine.

..... **[1]**

- ii. A patient was participating in influenza vaccination trials.

- On day 5 of the trial the patient was injected with antigens extracted from the influenza virus.
- On day 25 the patient was exposed to the influenza virus.
- The response of their immune system was monitored by regular blood tests to determine the quantity of antibodies in their blood.

Sketch a graph on the axes to show the possible primary **and** secondary immune response for this patient. Label **both** responses on your graph.



[2]

- iii. Outline the role of B memory cells in the secondary immune response.

[2]

16. What chemical is produced by plants in response to attack by pathogens?

- A Amylopectin
- B Amylose
- C Callose
- D Cellulose

Your answer

[1]

17. Different types of microorganism can act as pathogens.

Which of the diseases is caused by a pathogen without mitochondria in its cells?

- A** Black sigatoka in bananas
- B** Late blight in potatoes
- C** Ring rot in potatoes
- D** Ringworm in cattle

Your answer

[1]

18. Which of the following changes of lifestyle is/are likely to reduce the spread of a disease that is transmitted by droplets of moisture?

- 1 Clean drinking water
- 2 Fewer people living together in the same house
- 3 Housing with improved ventilation

- A** 1, 2 and 3
- B** Only 1 and 2
- C** Only 2 and 3
- D** Only 1

Your answer

[1]

19. Ash trees are an important part of the British landscape.

In 2012, a fungal disease known as ash dieback arrived in the UK from mainland Europe.

Which of the following could explain how ash dieback could have reached the UK from mainland Europe?

- 1 Spores carried on the wind
- 2 Young diseased trees imported from Europe and planted in the UK
- 3 Contaminated soil from a previously infected crop

- A** 1, 2 and 3
- B** Only 1 and 2
- C** Only 2 and 3
- D** Only 1

Your answer

[1]

20. Diseases can be caused by many different types of pathogen.

Which row matches the disease to the correct pathogen?

	Fungus	Protoctist	Virus
A	black sigatoka	tomato late blight	influenza
B	black sigatoka	tomato late blight	ring rot
C	tomato late blight	black sigatoka	influenza
D	tomato late blight	black sigatoka	ring rot

Your answer

☐

[1]

21. Which option describes the correct process of blood clotting?

- A** Platelets convert into insoluble fibrin to trap erythrocytes.
- B** The insoluble plasma protein fibrinogen converts into soluble fibrin to trap erythrocytes.
- C** The soluble plasma protein fibrinogen converts into insoluble fibrin to trap erythrocytes.
- D** The soluble plasma protein fibrinogen converts into soluble fibrin to trap erythrocytes.

Your answer

☐

[1]

22. Convalescent plasma immunity is one method used to treat patients infected with Ebola virus disease (EVD). In this method, blood plasma is taken from a person who has recovered from EVD and is injected into the patient with the EVD infection.

Which of the options describes this form of immunity?

- A** Artificial active immunity
- B** Artificial passive immunity
- C** Natural active immunity
- D** Natural passive immunity

Your answer

☐

[1]

END OF QUESTION PAPER