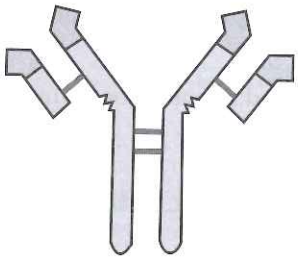
Cells and the Immune System — 1

Not all cells are as nice as the ones you've just seen — some are out to cause trouble. The following questions are all about disease and the immune response. I know, your primary response is going to want you to turn away from this page, but make sure you stick at it. You want to get those memory cells activated, ready for your exam.

1 **Figure 1** shows an antibody.

Figure 1



1.1 What is an antibody?

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(1 mark)

1.2 Name a type of cell that produces antibodies.

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(1 mark)

1.3 Explain how the structure of the antibody shown in **Figure 1** makes it adapted to its function.

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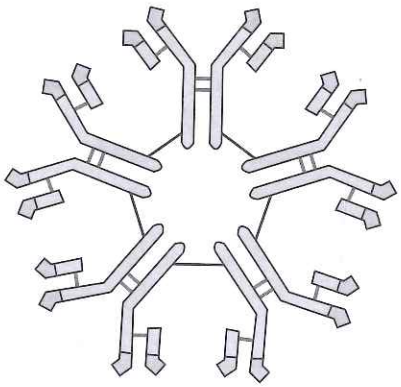
(3 marks)

Some antibodies have a more complex structure, made up of several monomers joined together. This is shown in **Figure 2**.

Figure 2



1.4 Suggest and explain **one** advantage of the structure in **Figure 2**, compared to that in **Figure 1**.

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(2 marks)

1.5 Some cells can produce antibodies at a rate of 2000 molecules per second.
Calculate how many antibodies would be produced by one of these cells in one hour.
Give your answer in standard form.

number of antibodies = ...

(2 marks)

2 Scientists are developing a vaccine against a viral disease that is often fatal in young children.

The vaccine has been tested on animals and is ready for human trials.
Initially, the vaccine is being tested on adults.

2.1 Suggest **two** factors the scientists should consider when selecting adult volunteers for this trial.

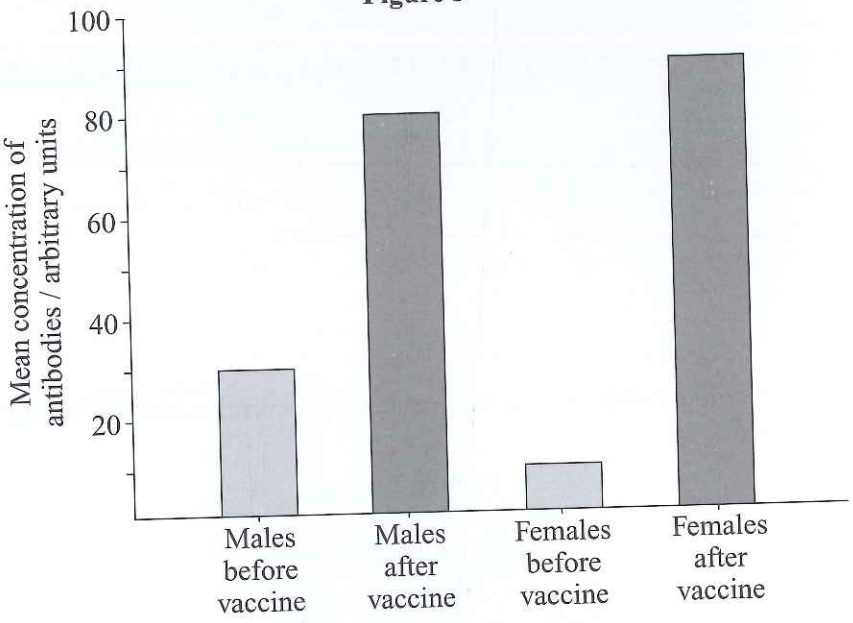
1. .....

2. .....

(2 marks)

Scientists conducting the trial compared the mean antibody concentration in males and females before and after the vaccine was administered. The results are shown in **Figure 3**.

Figure 3



2.2 Using the data in **Figure 3**, calculate the percentage change in mean antibody concentration for females after they received the vaccine.

percentage change = ...%

(1 mark)

2.3 Statistical tests on the difference between the mean antibody concentration in males and females showed a result of $P > 0.05$. Explain what this information tells you about the results.

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(2 marks)

The scientists are aiming to protect all children who are vulnerable to this disease by 2040.

2.4 Explain why it is possible to protect all children in a population without vaccinating them all.

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(2 marks)

Vaccination programmes are not always completely effective.
One possible cause for this lack of success is antigen variability.

2.5 Explain how antigen variability could prevent a vaccination programme from being entirely successful.

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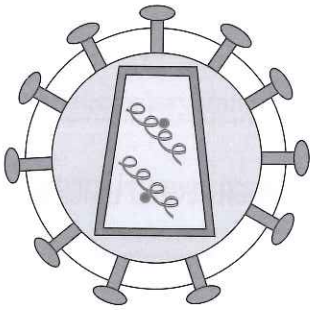
(3 marks)

3 **Figure 4** shows the structure of the human immunodeficiency virus (HIV).

Figure 4



3.1 On **Figure 4**, name and label the part of the virus which allows it to gain access to a host cell.

(1 mark)

3.2 HIV can only infect cells that express the CD4 cell-surface receptor, such as T-cells. Explain why.

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(3 marks)

HTLV-I is another virus that infects T-cells. It has the same structure as HIV and replicates the same way. The HTLV-I genetic material contains a gene called Tax. When T-cells express the Tax protein, they begin to divide uncontrollably.

3.3 Using this information, explain how a T-cell begins to express the Tax protein once the HTLV-I genetic material has gained access to the cell.

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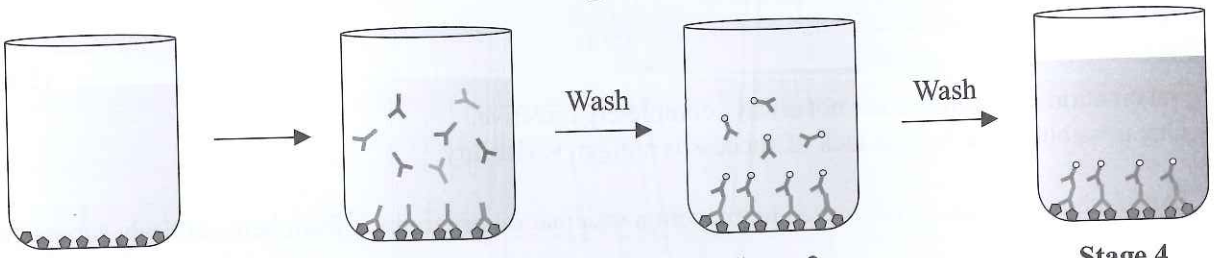
(4 marks)

4 Leishmaniasis is a parasitic disease spread through the bites of sandflies.
Figure 5 shows a method used for detecting the presence of *Leishmania* parasites in the blood.

Figure 5



Stage 1
Leishmania antigen bound to the surface of the well.

Stage 2
Patient's blood serum (containing antibodies) is added to the well.

Stage 3
Secondary antibody (with an enzyme attached) is added to the well.

Stage 4
Solution X added. A colour change indicates a positive result.

4.1 Name the procedure outlined in **Figure 5**.

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(1 mark)

4.2 Explain why only some antibodies in the patient's blood serum bind to the *Leishmania* antigen in **Stage 2**.

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(1 mark)

4.3 It is important to wash the surface of the well several times between **Stage 2** and **Stage 3**. Explain why.

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(2 marks)

4.4 Explain the role of the enzyme attached to the antibody in **Stage 3**.

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(1 mark)

4.5 The intensity of the colour that develops depends on the amount of antigen present.
Suggest why just looking for a colour change could make the test inaccurate.

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(1 mark)

To improve the accuracy of the results, an additional test is carried out to obtain quantitative results.

4.6 Suggest which test is carried out.

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(1 mark)

EXAM TIP

Lots of questions in the exam are put into a context, which is usually a situation or experiment you've not come across before. Don't panic. You just need to break down the question, using the knowledge you do have, and apply it to the context. So it doesn't matter if you've never heard of Leishmaniasis before, just use what you know about how monoclonal antibodies work.

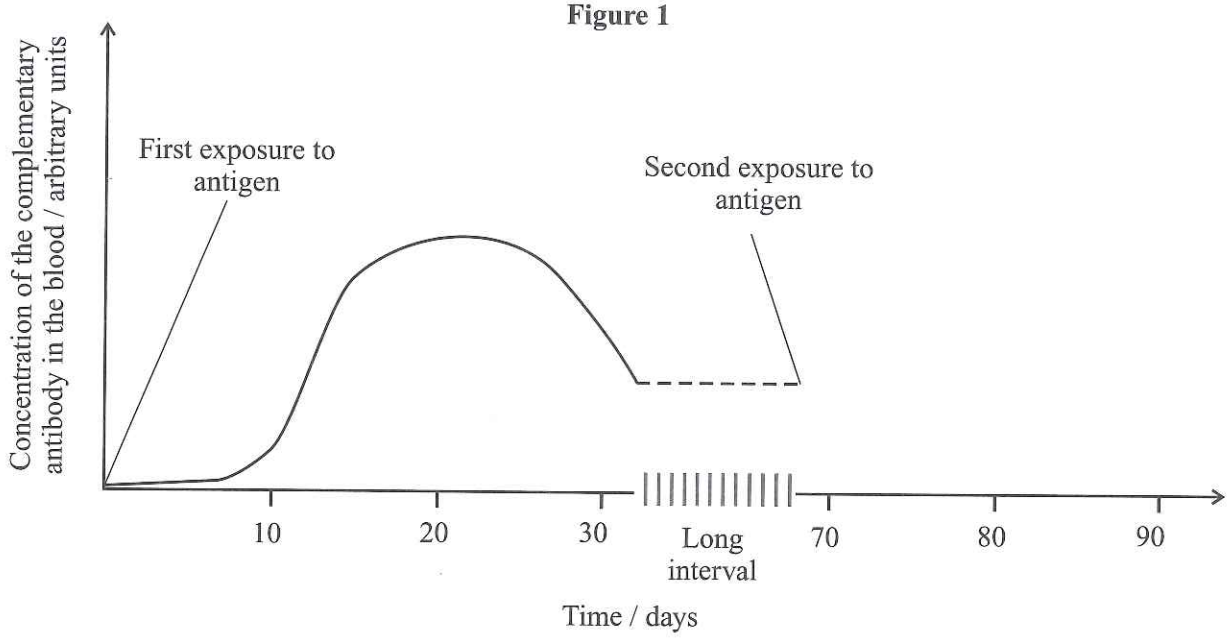
Score

34

Cells and the Immune System — 2

1 **Figure 1** shows the primary immune response following a bacterial infection.

Figure 1



1.1 On **Figure 1**, sketch a line to represent the secondary immune response.

(1 mark)

1.2 Explain the shape of the curve for the primary immune response.

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(4 marks)

2 Group B streptococcus (GBS) is a bacterium that can be carried, without harm, in a healthy human body. However, if a newborn baby becomes infected with GBS, it can lead to meningitis or other serious diseases.

GBS is typically passed on from a carrier mother to her baby during birth. Scientists are currently working to develop a vaccine against GBS, which will be given to pregnant women.

2.1 Suggest why a pregnant woman would be vaccinated against GBS when she is not at risk from infection.

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(1 mark)

2.2 Describe how a vaccine could lead to immunity against a GBS infection.

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(5 marks)

When a baby breastfeeds, it receives some of its mother's antibodies.
This gives the baby immunity against the diseases its mother is immune to.

2.3 Describe **two** differences between the immunity obtained from breastfeeding with the immunity obtained from a vaccine.

1. .....

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2. .....

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(2 marks)

Meningitis occurs when the protective layers around the brain and spinal cord become infected.
It can be caused by bacteria, such as GBS, or certain viruses.

2.4 Meningitis caused by GBS bacteria can be treated with the antibiotic cefotaxime.
Cefotaxime intereferes with cell wall synthesis.
Using this information, explain why viral meningitis cannot be treated with cefotaxime.

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(1 mark)

3 Alzheimer's disease is a brain disorder characterised by symptoms such as memory loss and confusion. Scientists think that Alzheimer's disease may be the result of structures called amyloid plaques developing in the brain. Several monoclonal antibodies are being trialled as drugs to treat those diagnosed with Alzheimer's disease. One such drug, gantenerumab, is a monoclonal antibody that targets a protein called beta-amyloid, which is the main component of amyloid plaques.

3.1 Using your knowledge of the immune response, suggest how a monoclonal antibody that targets beta-amyloid might work to destroy plaques.

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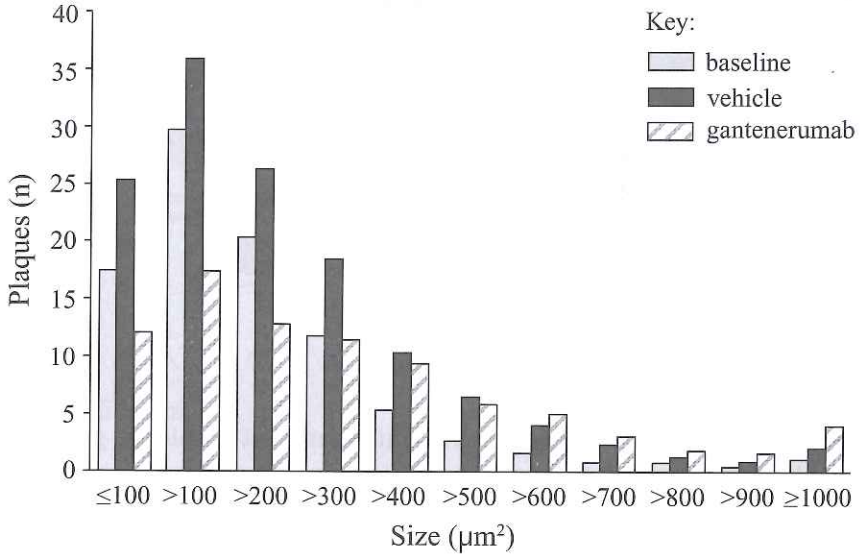
(2 marks)

A group of scientists investigated how well gantenerumab cleared beta-amyloid plaques in the hippocampus area of mice brains. Some of their results are shown in **Figure 2**.

Figure 2



- The baseline data in **Figure 2** shows the size and number of plaques in untreated mice at the start of the investigation.
- The vehicle data shows the size and number of plaques in mice treated only with the vehicle used to deliver the gantenerumab and not with the drug itself.
- Treatment with both the vehicle and gantenerumab lasted 5 months. Results were recorded at the end of this time period.

3.2 Explain why some mice were treated with the vehicle only.

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(2 marks)

3.3 Give **one** conclusion that can be drawn from the results shown in **Figure 2**.

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(1 mark)

3.4 A student looking at the data in **Figure 2** concluded that gantenerumab will be a useful treatment for Alzheimer's disease in humans.

Explain why this is not a valid conclusion.

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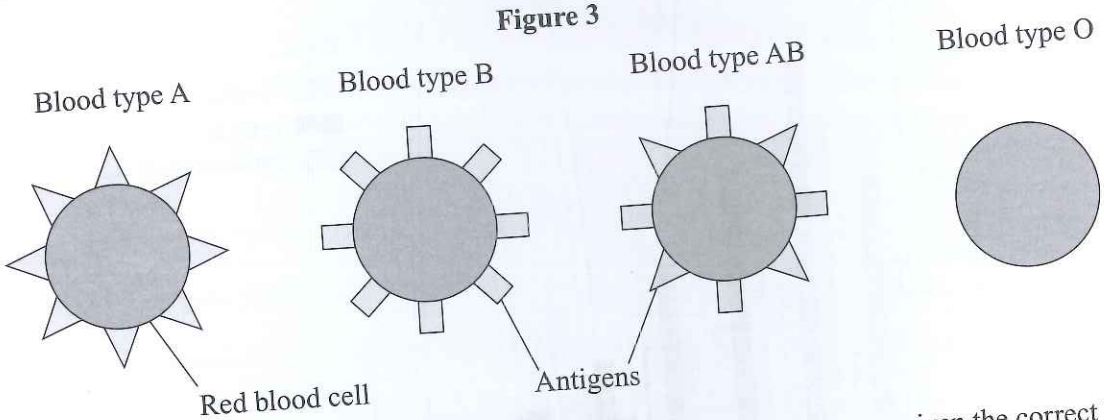
(4 marks)

4 **Figure 3** shows a simplified model of the different antigens present on red blood cells from different blood types.

Figure 3



4.1 Use the information in **Figure 3** to explain why it is important that people are given the correct blood type when receiving a blood transfusion.

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(3 marks)

4.2 Describe the sequence of events that would occur if **blood type B** was given to someone with **blood type A**.

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(6 mark

4.3 Explain why anyone can receive **type O** blood.

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4.4 Monoclonal antibodies can be used to determine a person's blood type. Suggest how.

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(2 ma

EXAM TIP

It's easy to get so bogged down trying to learn all the facts that you forget about practical skills — make sure you don't. Examiners love to bring bits from practical skills into questions to get you thinking outside the box. Make sure you know about things like experimental design, drawing conclusions, and validity, and that you can apply them to real-world examples.