11. Immunity

11.1 The Immune System

Paper 2

Question Paper

1 Alveolar macrophages are cells of the immune system that remain in the alveolar region of the gas exchange system. The macrophages protect against infection caused by pathogens that have been inhaled.

(b) Tuberculosis (TB) can be prevented if the bacterial cells that have reached the alveoli are rapidly destroyed. Alveolar macrophages can detect the presence of *M. tuberculosis* in the alveolar space and can carry out phagocytosis to form phagocytic vacuoles, such as the one shown in Fig. 2.1.

(i) Outline the sequence of events that leads to the formation of a phagocytic vacuole after detection of the bacterial cells by an alveolar macrophage.

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(ii) Name the cell structures that fuse with the phagocytic vacuole and release hydrolytic enzymes to destroy the bacterial cells.

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2 Adult stem cells are undifferentiated cells that are found in most animal tissues.

Adult stem cells can divide by mitosis throughout their lifespan to form identical stem cells (self-renewal) or to form cells that can differentiate into the functioning cells of that tissue.

(e) Fig. 4.1 shows that monocytes differentiate into cell type **X**, which has a similar function to neutrophils.

Name cell type **X**.

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(f) Cell type **Y** shown in Fig. 4.1 releases molecules with antigen binding sites.

Name the molecules released by cell type **Y**.

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(g) The differentiation of T-lymphocytes begins in the bone marrow and continues in an organ known as the thymus to produce fully differentiated T-helper and T-killer cells.

In the thymus, T-lymphocytes that bind to self antigens are destroyed.

Explain why T-lymphocytes that bind to self antigens need to be destroyed in the thymus.

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3 **(c)** Vaccination is another way of reducing the transmission of infectious diseases such as TB. The BCG vaccine is used to help control the spread of TB. This vaccine contains a weakened strain of the pathogen that causes TB. The BCG vaccine stimulates the development of antigen-specific memory T-lymphocytes.

Explain how memory T-lymphocytes provide protection from TB in a person who has been given a BCG vaccination.

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4 Cells of the immune system respond to the presence of non-self antigens.

(a) Outline the features of non-self antigens.

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(b) Four different types of cells of the immune system are shown in Table 3.1.

Complete Table 3.1:

- use a tick (✓) if the description applies to the named cell of the immune system
- use a cross (✗) if the description does **not** apply.

Table 3.1

description of cell	cell of the immune system			
	B-lymphocyte	**plasma cell**	**T-helper cell**	**T-killer cell**
able to go through a number of cell cycles (clonal expansion)				
main role is to secrete cytokine during an immune response				
present during a **primary** immune response to a virus				

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5 Fig. 3.1 shows some fruits (grapes) of the grapevine, *Vitis vinifera*.



Fig. 3.1

Sucrose is transported in the phloem of the grapevine to the fruits. In the fruits, sucrose is hydrolysed by the enzyme sucrase, which is found in cell walls. The glucose and fructose produced by the hydrolysis of sucrose pass through membrane proteins, known as hexose transporters, into the cytoplasm of the fruit cells.

(c) Fig. 3.3 is a diagram of a protein in the cell surface membrane of a macrophage from a mouse.

Macrophages use these proteins in antigen presentation. Non-self antigens bind to the proteins and are involved in the activation of specific T-lymphocytes during the immune response.

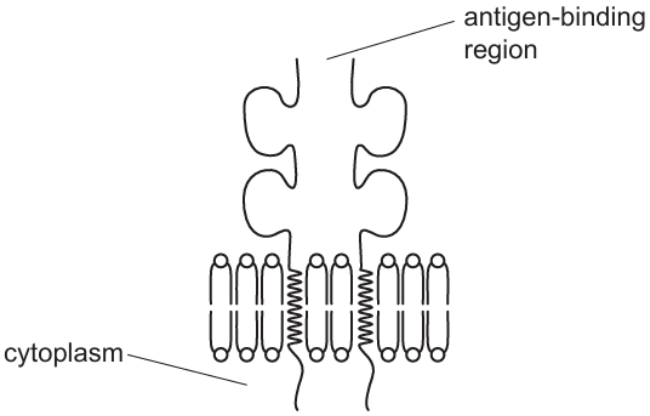


Fig. 3.3

(i) State what is meant by a non-self antigen.

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(ii) Some pathogens enter human cells. Macrophages partially digest these pathogens and present antigens to T-lymphocytes during immune responses.

With reference to Fig. 3.3, explain how T-lymphocytes respond to infection by a specific type of pathogen.

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6 The liver receives blood from the hepatic artery and from the hepatic portal vein. The hepatic portal vein transports blood from the digestive system.

Hepatocytes are the main cell type of the liver. They have a wide range of functions, including:

- the synthesis of triglycerides and plasma proteins
- detoxifying waste
- energy storage.

(b) Blood arriving at the liver enters specialised blood vessels known as sinusoids.

Fig. 3.1 is a diagram of part of a sinusoid and surrounding hepatocytes. A second type of cell found in the liver, a Kupffer cell, is also shown.

Kupffer cells are phagocytic cells of the immune system.

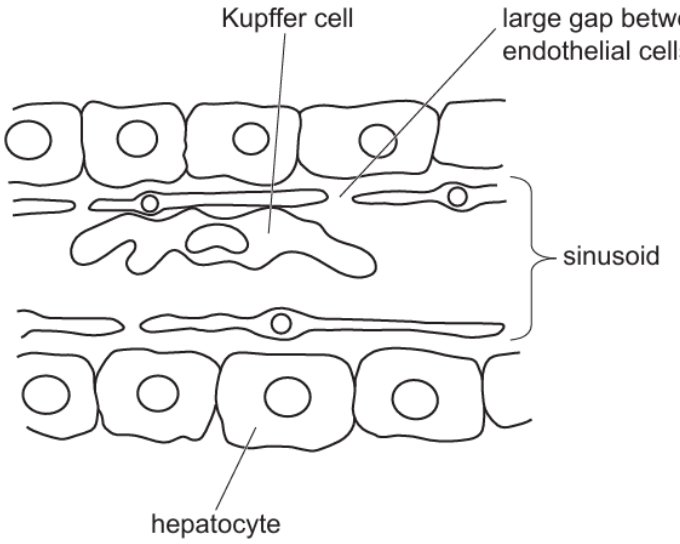


Fig. 3.1

(ii) In addition to removing bacteria present in the blood inside the sinusoid, Kupffer cells are also able to remove old or damaged red blood cells.

Describe the mode of action of a Kupffer cell in removing and breaking down a damaged red blood cell.

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7 Some people who are infected with HIV develop HIV/AIDS.

(b) People who develop HIV/AIDS have fewer T-helper cells as the pathogen destroys these cells. This makes them more susceptible to tuberculosis (TB).

Explain why people with HIV/AIDS are more likely to develop TB.

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8 Human cytomegalovirus (HCMV) is a common virus affecting humans. In people with a fully functioning immune system, infection by HCMV usually causes no, or only mild, symptoms.

Fig. 2.1**A** is a diagram of a section through HCMV. In Fig. 2.1**B**, only the outer part of HCMV is sectioned.

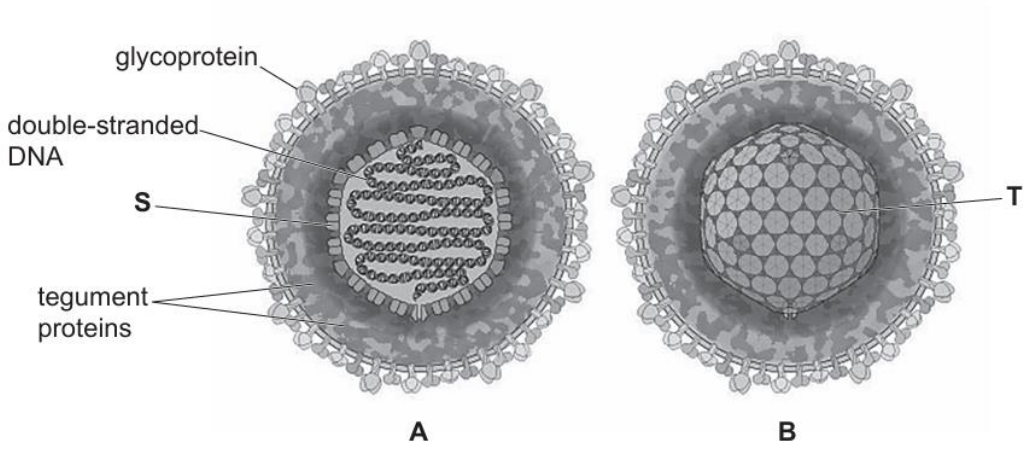


Fig. 2.1

The viral DNA shown in Fig. 2.1 contains genes that code for proteins important in viral replication and viral structure, including viral DNA polymerase and proteins known as tegument proteins.

Viruses can only replicate in host cells as they need to use processes and contents of the host cell. Complete viral particles that are released from the host cell are known as virions.

(g) After a person has been infected with HCMV, the virus remains in a dormant state in the body for life.

If the virus becomes active again (reactivates), the virus will only cause serious illness if the person has a weak immune system at that time.

Explain why the response to reactivation of HCMV is more likely to cause serious illness in a person who has a weak immune system.

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9 The diseases myasthenia gravis (MG) and HIV/AIDS both involve disorders of the immune system.

(a) The cause of MG involves a response by B-lymphocytes.

Explain why MG is called a disorder of the immune system.

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10 The causative organism of measles is *Morbillivirus*. Young children who have not been vaccinated for measles are at highest risk of becoming ill and of developing complications associated with the disease.

(e) A child with leukaemia is at high risk of developing measles even though the child has a high white blood cell count **and** has been vaccinated against the disease.

Explain why this child is at high risk of developing measles.

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11 Cholera is an infectious disease caused by the bacterial pathogen *Vibrio cholerae*.

(c) Vaccination can be used to prevent the spread of cholera. The vaccine used contains part of the choleragen molecule and also contains dead cells of *V. cholerae*.

(i) Phagocytes play an important role in the immune response to a vaccine. Phagocytes contain many lysosomes.

Describe the function of lysosomes in phagocytes.

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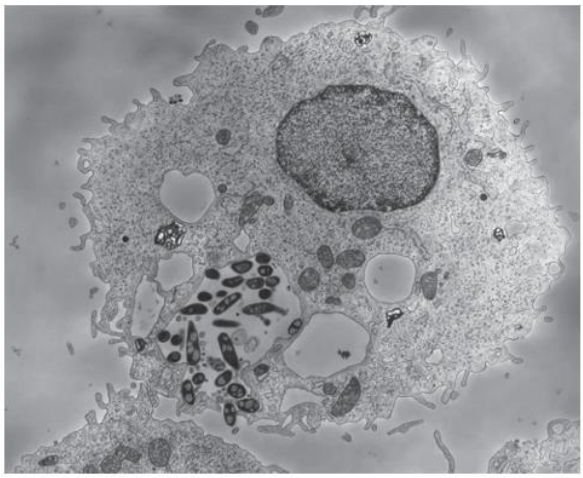
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12 The vaccine used to control tuberculosis (TB) is known as Bacillus Calmette-Guérin (BCG). The vaccine contains live bacteria that have been selected so that they do not cause disease in humans.

Fig. 5.1 shows a macrophage that is in the process of engulfing the bacteria in the vaccine.



magnification ×4400

Fig. 5.1

(b) Describe the events that occur in the body after the macrophage has engulfed the bacteria until the production of antibodies in response to the BCG vaccine.

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(c) Vaccines, such as BCG, stimulate the formation of memory cells.

Explain the role of memory cells in the body's defence against the TB pathogen.

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13 **(b)** Immunotherapy is a form of treatment for cancer which aims to stimulate the immune system to destroy tumour cells.

One form of immunotherapy for cancer uses a vaccine which contains one specific type of TSA.

(i) Describe how vaccination with a specific type of TSA could lead to the destruction of tumour cells by T-lymphocytes in the body.

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14 In the immune system, a plasma cell develops from an activated B-lymphocyte. Mature plasma cells synthesise and secrete antibody molecules.

(c) Clonal expansion also results in the production of memory B-lymphocytes.

Explain the importance of clonal expansion **and** the production of memory B-lymphocytes in providing protection for a person against an infectious disease.

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(d) Myasthenia gravis is an example of a disease where the immune system fails to distinguish between self and non-self.

Explain what is meant by this statement.

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15 Myasthenia gravis is a condition that results in muscle weakness by affecting the immune response.

(a) Explain what is meant by the term *immune response*.

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(b) Myasthenia gravis is an autoimmune disease which disrupts a cell signalling pathway involving muscle cells.

(i) Suggest how the immune system acts to disrupt this cell signalling pathway.

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16 Bacteria may be classified according to differences in cell wall structure. The differences are shown by using the Gram stain.

- A Gram-positive bacterium has a cell wall mainly composed of a thick layer of peptidoglycan (murein).
- A Gram-negative bacterium has a more complex cell wall. This wall is composed of a much thinner layer of peptidoglycan and an outer layer known as the outer membrane.

Escherichia coli is a Gram-negative bacterium.

Fig. 3.1 is a diagram through the cell surface membrane **and** the cell wall of *E. coli*.

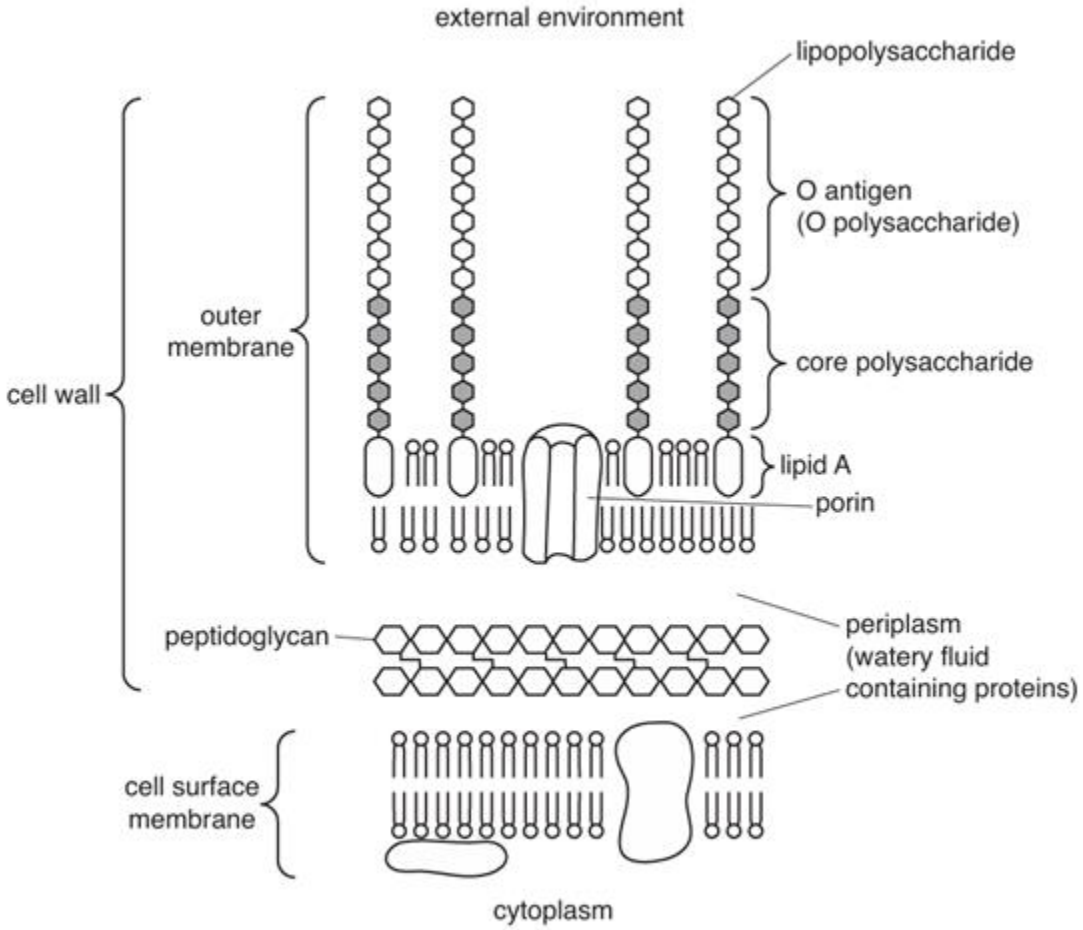


Fig. 3.1

(c) Fig. 3.1 shows that the outer membrane of the cell wall of *E. coli* contains lipopolysaccharides. These are not present in the cell surface membrane. Each lipopolysaccharide (LPS) consists of a lipid and a polysaccharide portion.

The O antigen is the outer part of the polysaccharide portion of the LPS. It faces the aqueous external environment.

(ii) Some strains of *E. coli* are pathogenic. Different pathogenic strains have different O antigens.

Suggest **and** explain why infection with one pathogenic strain of *E. coli* does not provide immunity to a different pathogenic strain.

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17 **(b)** Myasthenia gravis (MG) is described as an autoimmune disease. It is a long-term condition that results from a failure of the immune system.

(i) Explain why MG is known as an autoimmune disease.

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