**Q1.**

(a)  Describe how the human immunodeficiency virus (HIV) is replicated **once inside** helper T cells (TH cells).

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**(4)**

HIV-1 is the most common type of HIV. HIV-1 binds to a receptor on TH cells called CCR5.

Current treatment for HIV-1 involves the use of daily antiretroviral therapy (ART) to stop the virus being replicated. Only 59% of HIV-positive individuals have access to ART.

Scientists have found that two HIV-1-positive patients (**P** and **Q**) have gone into remission (have no detectable HIV-1). This happened after a blood stem cell transplant (BSCT).

•   Patient **P** was given **two** BSCTs, and patient **Q** was given **one** BSCT.

•   All BSCTs came from a donor with TH cells **without** the CCR5 receptor.

•   In addition, patient **P** had radiotherapy, and patient **Q** had chemotherapy. Both of these treatments are toxic.

•   **Both** patients (**P and Q**) stopped receiving ART 16 months after BSCT.

18 months after stopping ART, **both** patients had **no** HIV-1 RNA in their plasma, **no** HIV-1 DNA in their TH cells and **no** CCR5 on their TH cells.

(b)  Use the information given to evaluate the use of BSCT to treat HIV infections.

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**(5)**

**(Total 9 marks)**

**Q2.**

(a)     Describe how a phagocyte destroys a pathogen present in the blood.

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**(3)**

(b)     Give **two** types of cell, other than pathogens, that can stimulate an immune response.

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**(2)**

(c)     The diagram below shows the structure of an antibody.



Label the diagram above with an **X** to show where an antigen-antibody complex forms.

**(1)**

(d)     A disulfide bridge is labelled in the diagram above.

What is the role of the disulfide bridge in forming the quaternary structure of an antibody?

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**(1)**

**(Total 7 marks)**

**Q3.**

(a)     What is a **monoclonal** antibody?

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**(1)**

(b)  After a disease is diagnosed, monoclonal antibodies are used in some medical treatments.

Give **one** example of using monoclonal antibodies in a medical treatment.

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**(1)**

(c)  Describe the role of antibodies in producing a positive result in an ELISA test.

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**(4)**

**(Total 6 marks)**

**Q4.**

(a)  Describe the structure of the human immunodeficiency virus (HIV).

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**(4)**

Some people infected with HIV do not develop AIDS. These people are called HIV controllers.

Scientists measured the number of HIV particles (the viral load) and the number of one type of T helper cell (CD4 cells) in the blood of a group of HIV controllers and also in a group of HIV positive patients who had symptoms of AIDS.

The median values and the range of their results are shown in the table.

|  |  |  |
| --- | --- | --- |
| **HIV status of people** | **Median viral load / virus particles per cm3 of blood (range)** | **Median number of CD4 cells per mm3 of blood (range)** |
| HIV controllers | 212(<50 to 609) | 693(529 to 887) |
| HIV positive people with AIDS symptoms | 66 274 (30 206 to 306 163) | 248(107 to 365) |

(b)  A test sample of 500 mm3 of blood is taken from an HIV controller to determine the viral load.

Tick (**✓**) **one** box that shows the number of virus particles that would be present in a test sample of blood taken from an HIV controller with the median viral load.

|  |  |
| --- | --- |
| 106 000 |  |
| 10 600 |  |
| 1060 |  |
| 106 |  |

**(1)**

(c)  Use the data in the table above and your knowledge of the immune response to suggest why HIV controllers do not develop symptoms of AIDS.

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**(3)**

**(Total 8 marks)**

**Q5.**

(a)     Describe how phagocytosis of a virus leads to presentation of its antigens.

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**(3)**

(b)     Describe how presentation of a virus antigen leads to the secretion of an antibody against this virus antigen.

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**(3)**

(c)     Collagen is a protein produced by cells in joints, such as the knee.

Rheumatoid arthritis (RA) is an auto-immune disease. In an auto-immune disease, a person’s immune system attacks their own cells. RA causes pain, swelling and stiffness in the joints.

Scientists have found a virus that produces a protein very similar to human collagen.

Suggest how the immune response to this viral protein can result in the development of RA.

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**(2)**

**(Total 8 marks)**

**Q6.**

(a)     What is an antigen?

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**(2)**

(b)     What is an antibody?

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**(2)**

Poliomyelitis is an infection caused by a virus.

A doctor vaccinated a group of patients against poliomyelitis. He gave each patient two doses of vaccine, 3 months apart.

An immunologist tested three samples of blood from each of the patients:

•       (sample 1) taken 2 weeks before the first dose of vaccine

•       (sample 2) taken 2 weeks after the first dose of vaccine

•       (sample 3) taken 2 weeks after the second dose of vaccine.

He measured the concentration of antibodies against the poliomyelitis virus in the patients’ blood each time. The results are shown in the graph.



(c)     Calculate the percentage increase in the mean concentration of antibodies in blood between samples 2 and 3.

Answer = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ %

**(1)**

(d)     Explain the differences between the mean concentrations of antibodies in blood samples 1, 2 and 3.

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**(4)**

**(Total 9 marks)**

**Q7.**

(a)     When a vaccine is given to a person, it leads to the production of antibodies against a disease-causing organism. Describe how.

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**(5)**

(b)     Describe the difference between active and passive immunity.

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**(5)**

**(Total 10 marks)**

Mark schemes

**Q1.**

(a)     1.      RNA converted into DNA using reverse transcriptase;

*Reject ‘messenger’ or ‘m’ before RNA*

2.      DNA incorporated/inserted into (helper T cell) DNA/chromosome/genome/nucleus;

3.      DNA transcribed into (HIV m)RNA;

*Accept descriptions of transcription*

4.      (HIV mRNA) translated into (new) HIV/viral proteins (for assembly into viral particles);

*Accept descriptions of translation*

*Accept named viral protein, eg capsid*

*Reject viral cells*

**4**

(b)     For

1.      (There appears to be) no virus/ HIV(-1)/RNA/DNA, so could be a cure/effective;

*Max 4 for reasons for or against*

*Ignore virus is killed*

2.      No CCR5/receptor, so not get HIV(-1) in the future

**OR**

No CCR5/receptor, so nothing for HIV(-1) to bind to;

*Reject less CCR5/less HIV(-1) bind*

3.      Only one transplant/BSCT needed (shown by patient **Q**)

4.      Would not need (daily) ART (16 months after BSCT);

Against

5.      Don’t know if chemotherapy/radiotherapy is needed

**OR**

Do not know if BSCT alone would be effective;

**OR**

Do not know which treatment is having the effect

**OR**

Could be due to chemotherapy/radiotherapy;

Accept: chemotherapy/radiotherapy is toxic/harmful/has side-effects

6.      Only for HIV-1;

*Accept: Might not work in other types of HIV*

7.      Don’t know if it would work in all people

**OR**

Only worked/tried in 2 cases;

8.      Might not be long term

**OR**

Only 18 months;

9.      HIV-1 may mutate and be able to bind to a different receptor (on TH cells);

10.      Might be a lack of (suitable stem cell/BSCT) donors;

*Accept stem cells/BSCT (might be) rejected*

**5 max**

**[9]**

**Q2.**

(a)  1.      Engulfs;

*Accept endocytosis*

***OR***

*Description*

*Ignore ‘taken in’*

2.      Forming vesicle/phagosome **and** fuses with lysosome;

3.      Enzymes digest/hydrolyse;

*Accept lysozymes for ‘enzymes’*

**3**

(b)     1.      (Cells from) other organisms/transplants;

2.      Abnormal/cancer/tumour (cells);

3.      (Cells) infected by virus;

*Accept ‘own cells’ if autoimmune response suggested*

*Accept APCs*

*Accept non-self*

**2 max**

(c)     ‘X’ written at either or both ends of Y shape;

**1**

(d)     Joins two (different) polypeptides;

*Accept holds/attaches*

*Accept ‘prevents polypeptide chains separating’*

**1**

**[7]**

**Q3.**

(a)  (Antibodies with the) same tertiary structure

**OR**

(Antibody produced from) identical/cloned plasma cells/B cells/B lymphocytes;

*Accept in context of single plasma/B cell/B lymphocyte*

*Reject: genetically identical antibody*

**1**

(b)  Accept any **one** suitable use, eg

Targets/binds/carries drug/medicine to specific cells/antigens/receptors

**OR**

Block antigens/receptors on cells;

*Accept cancer/diseased cells (as a specific cell).*

*Ignore medical diagnosis/pregnancy/ PSA/ELISA test.*

**1**

(c)

*Ignore mixing of direct or indirect ELISA*

*Accept annotated diagram(s).*

1.   (First) antibody binds/attaches /complementary (in shape) to antigen;

2.   (Second) antibody with enzyme attached is added;

3.   (Second) antibody attaches to antigen;

*Accept (second) antibody attaches to (first) antibody (indirect ELISA test).*

4.   (Substrate/solution added) and colour changes;

*Only award if enzyme mentioned.*

**4**

**[6]**

**Q4.**

(a)

*Accept a labelled diagram.*

1.   RNA (as genetic material);

*Reject nucleus/DNA/plasmids.*

2.   Reverse transcriptase;

3.   (Protein) capsomeres/capsid;

*Reject capsule.*

4.   (Phospho)lipid (viral) envelope

**OR**

Envelope made of membrane;

*Reject if HIV has a cell membrane or a cell wall.*

5.   Attachment proteins;

*Accept gp41 and/or gp 120.*

*Accept glycoprotein.*

*Accept description of attachment protein.*

*Ignore ‘receptor protein’.*

*Ignore cytoplasm.*

**4 max**

(b)  Automarked q – ☑ 106

**1**

(c)  1.   (All) have more T helper/CD4 cells;

*Accept higher proportion of T helper/CD4 to virus particles.*

*Statement must be comparative.*

2.   Lower viral load **to** infect/destroy helper T/CD4 cells;

*For ‘infect’ accept ‘HIV does not reproduce in’.*

*Statement must be comparative.*

3.   (So more/continued) activation of B cells/cytotoxic T cells/phagocytes;

*Accept ‘stimulation’ for ‘activation’.*

4.   (With B cells more/continued) production of plasma cells/antibodies

**OR**

(With cytotoxic T cells more/continued) ability to kill virus infected cells;

*Ignore reference to B cells acting as phagocytes/antigen-presenting cells.*

5.   (More able to) destroy other microbes/pathogens

**OR**

(More able to) destroy mutated/cancer cells;

**3 max**

**[8]**

**Q5.**

(a)     1.      Phagosome / vesicle fuses with lysosome;

2.      (Virus) destroyed by lysozymes / hydrolytic enzymes;

3.      Peptides / antigen (from virus) are displayed on the cell membrane;

*1.      Accept vacuole fuses with lysosome*

*1.      Reject virus fuses with lysosome*

**3**

(b)     1.      Helper T cell / TH cell binds to the antigen (on the antigen-presenting cell / phagocyte);

2.      This helper T / TH cell stimulates a specific B cell;

3.      B cell clones

**OR**

B cell divides by mitosis;

4.      (Forms) plasma cells that release antibodies;

*1. and 2. ‘Helper’ is required* ***once*** *only.*

*2.      Accept ‘This (helper) T cell stimulates a competent B cell’*

*‘T cell stimulates B cell to undergo clonal selection’. This statement achieves mp2 and mp3.*

**3 max**

(c)     1.      The antibody against virus (antigen) will bind to collagen;

2.      This results in the destruction of the (human) cells / collagen;

*2.      Ignore ‘attacks’*

**2**

**[8]**

**Q6.**

(a)     1.      Foreign protein;

*Accept glycoprotein / glycolipid / polysaccharide*

2.      (that) stimulates an immune response / production of antibody;

**2**

(b)     1.      A protein / immunoglobulin specific to an antigen;

2.      Produced by B cells

**OR**

Secreted by plasma cells;

**2**

(c)     1750(%);

**1**

(d)     1.      Sample 1 / before vaccination no antibody released because patients not yet encountered vaccine / antigen / virus;

*Accept ‘produced’ for ‘released’*

2.      (Sample 2 / primary response / after first dose) activation / clonal selection / expansion of B cells into plasma cells;

3.      Plasma cells release antibodies;

4.      (Sample 3 / secondary response / after second dose) memory cells produce more antibodies / produce antibodies more quickly;

**4**

**[9]**

**Q7.**

(a)     1.      Vaccine contains antigen from pathogen;

2.      Macrophage presents antigen on its surface;

3.      T cell with complementary receptor protein binds to antigen;

4.      T cell stimulates B cell;

5.      (With) complementary antibody on its surface;

6.      B cell secretes large amounts of antibody;

7.      B cell divides to form clone all secreting / producing same antibody.

**5 max**

(b)     1.      Active involves memory cells, passive does not;

2.      Active involves production of antibody by plasma cells / memory cells;

3.      Passive involves antibody introduced into body from outside / named source;

4.      Active long term, because antibody produced in response to antigen;

5.      Passive short term, because antibody (given) is broken down;

6.      Active (can) take time to develop / work, passive fast acting.

**5 max**

**[10]**