Q1.

(a) Give **two** ways in which pathogens can cause disease.

1. _____

_____

2. _____

_____

(2)

(b) Putting bee honey on a cut kills bacteria. Honey contains a high concentration of sugar.

Use your knowledge of water potential to suggest how putting honey on a cut kills bacteria.

_____

_____

_____

_____

_____

_____

_____

[Extra space] _____

_____

_____

(3)

(Total 5 marks)

Q2.

Read the following passage.

Chlamydia is a bacterium. Scientists have shown that infection with chlamydia can cause heart disease in humans. Infection with the bacterium can stimulate the formation of atheroma. This can lead to a heart attack.

Other scientists have been working with mice. These scientists have suggested that chlamydia may cause heart disease in a different way. They have found a protein on the surface of chlamydia cells which is similar to a protein in the heart muscle of mice. After an infection with chlamydia, cells of the immune system of the mice may attack their heart muscle cells and cause heart disease.

Use the information in the passage and your own knowledge to answer the following

questions.

(a) (i) Using information from the passage, explain what is meant by an antigen.

_____

_____

_____

_____

(2)

(ii) After an infection with chlamydia, cells of the immune system of the mice may attack the heart muscle cells (lines 7-8). Explain why.

_____

_____

_____

_____

_____

(2)

(b) Some scientists have suggested that people should be vaccinated to prevent infection by chlamydia. Evaluate this suggestion.

_____

_____

_____

_____

_____

_____

*(Extra space)*_____

_____

_____

(3)

(Total 7 marks)

Q3.

The box jellyfish produces a poison (venom) which enters the blood when a person is stung. A person who has been stung can be treated with an injection of antivenom. This antivenom is produced by injecting small amounts of venom from box jellyfish into sheep, then extracting antibodies from the sheeps' blood. These antibodies are then injected into the person who has been stung.

(a) If a sheep is injected with the box jellyfish venom on more than one occasion a higher yield of antivenom is obtained. Explain why.

_____

_____

_____

_____

(2)

(b) Injecting antivenom does not give a person lasting protection against the venom of box jellyfish. Explain why.

_____

_____

_____

_____

(2)

(c) Suggest **one** possible problem in injecting people with antivenom made in this way.

_____

_____

(1)

(Total 5 marks)

Q4.

Vaccines protect people against disease. Explain how.

(Total 5 marks)

Q5.

Ebola is a disease caused by a virus. The Ebola virus has a glycoprotein on its surface
which binds to a specific receptor protein in the cell-surface membranes of human cells.
When it binds to this receptor protein, the virus can enter the cell. Some people do not
produce this receptor protein. These people may become infected with the Ebola virus
but do not develop the disease.

A blood test can be used to determine whether a person has Ebola. People with Ebola
have large numbers of specific plasma cells and a specific antibody in their blood.
Some scientists have suggested treating people suffering from Ebola by using transfusions of blood plasma from people who have recently recovered from the disease.

The Ebola virus has a high mutation rate. This makes it difficult to develop a vaccine.

(a) People who do not have the specific receptor protein in their cell-surface membranes may be infected with the Ebola virus but do not develop the disease (lines 1–5).

Explain why they do **not** develop the disease.

(2)

(b) Explain the increase in specific plasma cells and antibody in people infected with the Ebola virus.

(2)

(c) Explain how a blood transfusion from a patient recently recovered from Ebola may be an effective treatment (lines 8–10).

(3)

(d) A high mutation rate makes it difficult to develop a vaccine (line 11).

Explain why.

(3)

(Total 10 marks)

Q6.

(a) Human papilloma virus (HPV) is the main cause of cervical cancer. A vaccine has been developed to protect girls and women from HPV.

Describe how giving this vaccine leads to production of antibody against HPV.

(4)

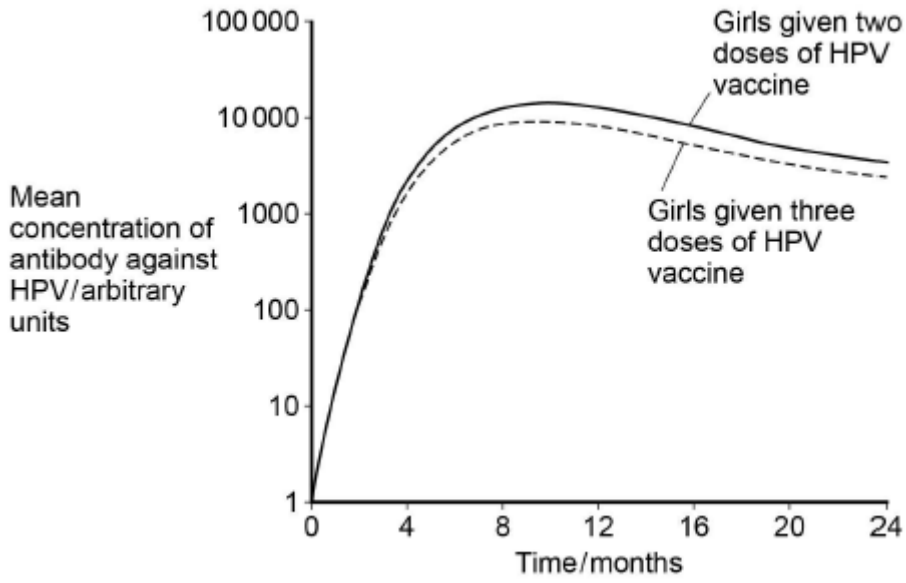
(b) Doctors investigated whether it was better to give two or three doses of the HPV vaccine. They determined the mean concentration of antibody against HPV in blood samples from girls who were given either two or three doses of the vaccine.

- Girls given two doses received an initial vaccination, followed by a second at 6 months.

- Girls given three doses received an initial vaccination, followed by a second at 1 month and a third at 6 months.

The doctors measured the concentration of antibody each month.

The results are shown below.



What do these results suggest about whether it is better to give two or three doses of the vaccine? Give reasons for your answer.

_____

_____

_____

_____

_____

(2)

(c) The doctors carried out a statistical test to determine whether the antibody concentrations were significantly different in girls given two doses of the vaccine, compared with those given three doses. They determined the mean concentrations of antibody 9 months after the first dose of vaccine.

What statistical test should the doctors have used? Give the reason for your choice.

Test _____

Reason _____

_____

(1)

(d) There is genetic diversity within HPV.

Give **two** ways doctors could use base sequences to compare different types of HPV.

1. _____

_____

2. _____

_____

(2)

(Total 9 marks)

Q7.

Read the following passage.

Sizes of populations of normal intestinal bacteria are usually controlled by T cells that are produced slowly and in small numbers by the immune system. These T cells do not normally survive for very long. As a result, they do not release large amounts of cytokines. Cytokines are chemicals that can cause swelling of the lining of the intestines.

Crohn's disease is a long-lasting disease that causes swelling of the lining of the intestines. It is believed that Crohn's disease can be caused by a loss of tolerance to normal intestinal bacteria, as shown by an unusually large response by T cells. This response can be triggered by pathogenic bacteria in the intestines of people with a genetic tendency to Crohn's disease.

Some people's Crohn's disease can be controlled by a drug called 5-aminosalicylic acid (5-ASA) that reduces swelling. Another drug called 6-mercaptopurine (6-MP) may also be used. 6-MP inhibits an enzyme required to make adenine and guanine. This is effective because most cells can recycle nucleotides, but T cells are not able to do so.

Use information from the passage and your own knowledge to answer the questions.

(a) The Crohn's disease symptom of swelling of the lining of the intestines could be triggered by pathogenic bacteria in the intestines (lines 6–10).

Suggest how.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(b) Suggest the meaning of ‘a genetic tendency to Crohn’s disease’ (line 10).

(2)

(c) Suggest why 5-ASA is only effective in controlling the swelling of the lining of the intestines in **some** people with Crohn’s disease (lines 11–12).

(2)

(d) Suggest why 6-MP can be used to control the symptoms of Crohn's disease (lines 13–15).

Do **not** include details of enzyme inhibition or protein synthesis in your answer.

(3)

(Total 10 marks)

Q8.

(a) An antigen in a vaccine leads to the production of antibodies. Describe the part played by B lymphocytes in this process.

(4)

(b) Hepatitis B vaccine contains a viral antigen produced by genetically modified bacteria. Describe how the isolated gene that codes for a protein in the virus's coat could be transferred to the bacterial cells.

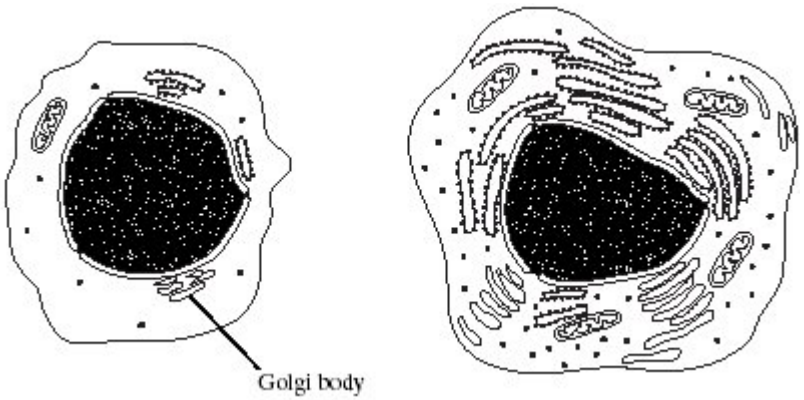
(3)
(Total 7 marks)

Q9.

(a) Changes to the protein coat of the influenza virus cause antigenic variability. Explain how antigenic variability has caused some people to become infected more than once with influenza viruses.

(2)

(b) The drawings show the changes in a B lymphocyte after stimulation by specific antigens.



B lymphocyte before stimulation B lymphocyte after stimulation

(i) Describe the role of macrophages in stimulating B lymphocytes.

_____

_____

(1)

(ii) Explain how the changes shown in the drawings are related to the function of B lymphocytes.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 7 marks)

Q10.

(a) Give **two** factors, other than cost, that should be considered when selecting an antibiotic to treat a bacterial disease.

1. _____

_____

2. _____

_____

(2)

(b) The table describes the effects of two antibiotics on bacteria.

Antibiotic	Effect
Tetracycline	prevents tRNA binding
Chloramphenicol	prevents peptide bonds forming

(i) Explain how each of these antibiotics slows down the rate of growth of bacteria.

Tetracycline _____

Chloramphenicol _____

(4)

(ii) Suggest why tetracycline has no effect on human cells.

(1)

(Total 7 marks)

Q11.

Read the following passage.

The life cycle of the malarial parasite consists of a number of stages. Some of these stages occur in humans and some occur in mosquitoes. At each stage, the parasite has different antigens on the surface of its cells. Attempts have been made to extract some of these antigens and use them to make vaccines to combat the disease. A trial has recently been carried out with one of these vaccines. An injection of the vaccine was given to a group of people chosen at random at the start of the trial. Another injection was given 30 days later.

Blood samples were taken at regular intervals throughout the trial. After the first injection, the concentration of antibody in the blood rose slowly then fell quickly. After the second injection, the concentration rose quickly. It reached a maximum concentration of approximately twice the concentration it reached after the first injection.

Use information from the passage and your own knowledge to answer the following questions.

(a) What is meant by *antigens* (line 3)?

(2)

(b) (i) Use information from the passage to sketch a graph to show the effects of the two injections on the concentration of antibody in the blood.

(3)

(ii) Suggest **one** reason why it was necessary to give two injections of the vaccine
(line 6).

_____

_____

(1)

(iii) Although this vaccine is made from antigens from malarial parasites, it does not cause malaria. Explain why this vaccine does not cause malaria.

_____

_____

_____

_____

(2)

(c) The blood from those taking part in the trial was also examined under the microscope at the beginning of the trial. Explain how this would enable those who had malaria to be identified.

_____

_____

(1)

(Total 9 marks)

Q12.

Read the following passage.

Herpes simplex virus (HSV) infects nerve cells in the face, including some near the lips. Like many other viruses, HSV can remain inactive inside the body for years. When HSV becomes active, it causes cold sores around the mouth.

Human cells infected with a virus may undergo programmed cell death. While HSV is inactive inside the body, only one of its genes is transcribed. This gene is the latency-associated transcript (*LAT*) gene that prevents programmed cell death of an infected nerve cell.

Scientists have found that transcription of the *LAT* gene produces a microRNA. This microRNA binds to some of the nerve cell's own mRNA molecules. These

mRNA molecules are involved in programmed cell death of nerve cells. The scientists concluded that production of this microRNA allows HSV to remain in the body for years. 10

Use information from the passage and your own knowledge to answer the following questions.

(a) HSV infects nerve cells in the face (line 1). Explain why it infects **only** nerve cells.

(Extra space) _____

(3)

(b) HSV can remain inactive inside the body for years (lines 2–3). Explain why this virus can be described as **inactive**.

(2)

(c) Suggest **one** advantage of programmed cell death (line 4).

(1)

(d) The scientists concluded that production of this microRNA allows HSV to remain in the body for years (lines 10–12).

Explain how this microRNA allows HSV to remain in the body for years.

(Extra space) _____

(4)

(Total 10 marks)

Q13.

(a) What is an antigen?

(2)

(b) What is an antibody?

(2)

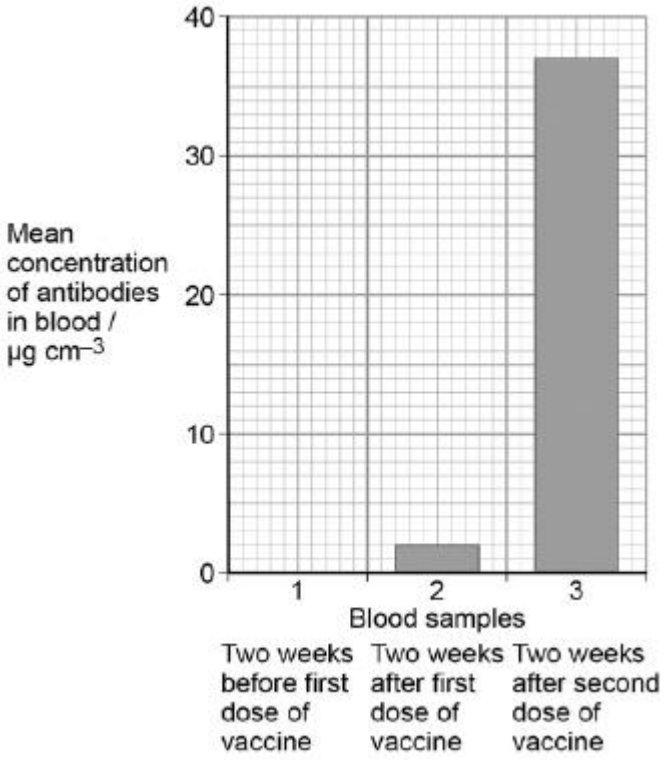
Poliomyelitis is an infection caused by a virus.

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.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 9 marks)

Q14.

(a) NMO is a disease that leads to damage to nerve cells in the spinal cord.
A person with NMO produces anti-AQP4 antibody that attacks only these nerve cells.

Explain why the anti-AQP4 antibody only damages these cells.

_____

_____

_____

_____

_____

_____

_____

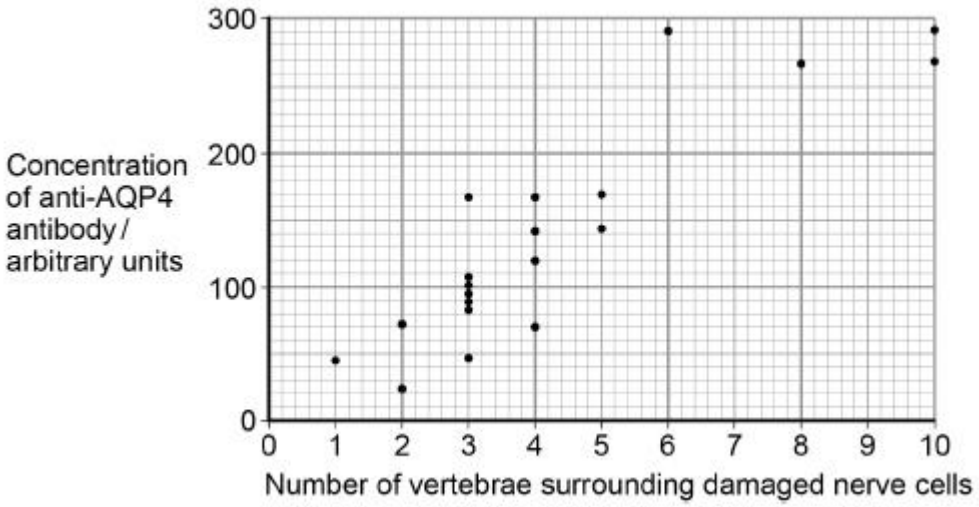
_____

(4)

(b) Scientists measured the concentration of anti-AQP4 antibody in the blood of people with NMO.

The spinal cord is surrounded by small bones called vertebrae. For each person, the scientists also determined the number of vertebrae surrounding damaged nerve cells.

Their results are shown in the graph.



A scientist suggested that the concentration of anti-AQP4 antibody in a person's blood could be used to predict the number of vertebrae surrounding damaged nerve cells they are likely to have.

Use the graph above to suggest reasons why this suggestion might **not** be valid.

(3)

(c) A new treatment for NMO involves using a monoclonal antibody. The structure of the variable region of this monoclonal antibody is identical to the variable region of an anti-AQP4 antibody, but the rest of its structure is different.

Use this information and your knowledge of antigen-antibody complexes to suggest how this monoclonal antibody prevents anti-AQP4 damaging nerve cells.

(2)

(Total 9 marks)

Q1.

(a) 1. (Releases) toxins;
2. Kills cells / tissues.

2. Accept any reference to cell / tissue damage

Ignore infecting / invading cells

2

(b) 1. Water potential in (bacterial) cells higher (than in honey) / water potential in honey lower (than in bacterial cells);

Q candidates must express themselves clearly

1. Must be comparative e.g. high WP in cell and low WP in honey

2. Water leaves bacteria / cells by osmosis;
3. (Loss of water) stops (metabolic) reactions.

3. Needs a reason why lack of water kills the cell

3

[5]

Q2.

(a) (i) Protein on (surface of) chlamydia;

That initiates an immune response (in mice) / causes antibody production;

Neutral "foreign protein"

Do not accept glycoprotein.

2. Accept description of initiating immune response.

2

(ii) 1. Antibodies / memory cells against chlamydia (protein / antigen) are present;

2. Protein on heart (muscle) similar to chlamydia protein / antigen so T cells / antibodies (attack heart muscle cells);

2. Look for idea that both proteins are similar

2. Detail of what is attacking the heart muscle cells

2

(b) **FOR**

1. Prevents / reduces heart disease / attacks;

2. Cheaper to vaccinate than treat heart disease;

AGAINST

3. Vaccination costly;

4. Don't know frequency of chlamydia infection;

5. Research in mice might not be replicated in humans / humans might have a different protein;

6. Vaccine could cause heart disease or immune response against heart (muscle);

2 max for arguments against

Accept other valid answers

3 max

[7]

Q3.

(a) Stimulates memory cells;

Secondary response, so antivenom / antibodies produced quicker;

2

(b) Passive immunity; so no memory cells produced;

Antivenom breaks down / destroyed;

2

(c) Could transfer disease / Allergy / Immune response to antibodies from animal;

1

[5]

Q4.

1. Vaccines contain antigens / dead / weakened pathogens / antigens dead / weakened pathogens are injected;

Ignore references to T or B cells.

2. Memory cells made;

3. On second exposure memory cells produce antibodies / become active / recognise pathogens;

3. Idea of memory cells responding.

4. <u>Rapidly</u> produce antibodies / produces <u>more</u> antibodies;

4. Production of antibodies must be qualified for mark. Underlined ideas essential.

5. Antibodies destroy pathogens;

5. Accept bacteria / viruses etc but not disease

[5]

Q5.

(a) 1. Virus can't bind (to receptor)/ can't enter cells;

2. So can't be replicated/ multiply;

Accept can't reproduce

3. So, doesn't damage cell(s)/tissues (and cause symptoms);

Accept no toxins released

2 max

(b) 1. Antigen/glycoprotein on Ebola binds to/stimulates (a specific) B cell;

Accept correct reference to stimulation of B cells by T cells

2. (Binding causes) replication/cloning of B cell;

Accept replication/cloning of plasma cell;

3. Plasma cells/B cells release/produce antibodies;

2 max

(c) 1. Lots of antibodies (against Ebola) in recovered patient;

2. Transfusion/plasma contains antibodies;

Ignore reference to cells

3. Antibodies (specific so) will bind with (Ebola) antigen;

4. (In recipient) virus destroyed/cannot enter cell;

Antigen destroyed is insufficient

3 max

(d) 1. (High mutation rate leads to) antigens change/antigenic variability;

Accept (high mutation rate leads to) changes in base sequence coding for antigen;

2. Vaccine contains specific antigen;

3. Antibodies not complementary to (changed) antigen / won't bind to (changed) antigens;

3

[10]

Q6.

(a) 1. Vaccine/it contains antigen (from HPV);

Term 'antigen' may be first mentioned with point 2

2. Displayed on antigen-presenting cells;

Accept named example, e.g. macrophage/phagocyte/B cells

3. Specific helper T cell (detects antigen and) stimulates specific B cell;

Accept 'helper T cell with receptor on surface' for 'specific' and B cells with receptor/antibody on surface that bind to antigen for 'specific'

4. B cell divides/goes through mitosis/forms clone to give plasma cells;

5. B cell/plasma cell produces antibody;

4 max

(b) 1. Two (doses) because got more antibody;

Accept more effective in producing antibody

2. With three doses, second dose/dose at 1 month doesn't lead to production of any more antibody (than the two-dose group)/get same/similar response;

3. Three doses would be more expensive/less popular with parents/girls (and serves no purpose);

Accept 'less painful'

2 max

(c) t-test, because comparing two means;

Mark for correct test and explanation correct

Accept 'comparing the mean'

Reject 'to show that the results/means are significant'

1

(d) 1. Compare (base sequences of) DNA;
2. Look for mutations/named mutations (that change the base sequence);
3. Compare (base sequences of) (m)RNA;

1 and 3 accept triplet/codon sequences for comparisons

Ignore references to 'introns/non-coding DNA'

2 max

[9]

Q7.

(a) 1. (Presence of) antigen of the (pathogenic) bacteria;

Assume bacteria are pathogenic unless otherwise stated

2. (Causes) more T cells produced / faster T cell production;

3. Against (the pathogen and) normal bacteria;

4. (Long lasting as) cells do not die / live for longer;

5. (More) cytokines / chemicals causing swelling are produced;

3 max

(b) 1. (Some people) have a mutation / allele / gene;

2. (That) increases the chances / risk / makes it more likely for / causes them to have an unusually large T cell response;
OR
(That) lowers / removes tolerance to (normal) intestinal bacteria;

2

(c) 1. (Some people might) produce (very) large amounts of cytokine / have large amounts of swelling;

2. (That) 5-ASA drugs cannot control / reduce;

OR

3. Some people may be allergic to / cannot tolerate 5-ASA;

4. So cannot take it;

Award 1 and 2

OR

Award 3 and 4

2

(d) 1. (Lack of adenine and guanine) will slow / stop DNA synthesis / replication (in T cells);

2. Affects T cells **more** as they cannot recycle nucleotides;

Needs idea of more / greater effect.

Accept converse idea that 'other' cells not as affected as they can recycle nucleotides.

3. (6-MP therefore) suppresses / slows the (unusually large) T cell / immune response
OR
(6-MP causes) fewer / no T cells (to be) produced;
Accept (6-MP) acts as an immunosuppressant drug

4. (So) less cytokine is produced (and therefore less swelling);

3 max

[10]

Q8.

(a) 1 macrophages present antigens to B lymphocytes;
2 antigen binds to / is complementary to receptors on lymphocyte;
3 binds to a specific lymphocyte;
4 lymphocytes become competent / sensitised;
5 (B) lymphocytes reproduce by mitosis / (B) lymphocytes cloned;
6 plasma cells secrete antibodies;

4 max

(b) 1 restriction enzyme / endonuclease;
2 to cut plasmid / to form sticky ends in plasmid;
3 (use) ligase(to join) gene to plasmid;
4 culture bacteria with (in medium containing) plasmids
5 to allow uptake of plasmids / transformation;
6 use of cold shock / chemical treatment (to enhance uptake) / heat shock;
(ignore bullets / electroporation / microinjection)

3 max

[7]

Q9.

(a) memory B / T cells do not recognise (new antigens);
antibodies previously produced are not effective
as shape not complementary to new antigen;

2

(b) (i) antigen in membrane presented to lymphocytes /
produce cytokinins;

1

(ii) mitochondria provide (more) ATP / energy;
(more) RER / ribosomes synthesise proteins;
(more) Golgi body secretes / modifies or packages proteins / produces glycoproteins;
(B lymphocytes) produces antibodies;

4

[7]

Q10.

(a) side effects / allergic reactions / low toxicity to cells;
interaction with other drugs / effective in conditions of use / reasonably stable;
should only act on the problem bacteria / narrow spectrum;
how much resistance the bacteria have built up;

2 max

(b) (i) tetracycline
prevents tRNA binding to ribosomes / amino acid / mRNA;

1

amino acids not available / brought / picked up;

1

chloramphenicol
prevents amino acids being joined / prevents primary structure forming;

1

no enzymes / no structural proteins formed;

(accept cell wall formation if qualified) (prevents protein synthesis gains one mark in either section, once only)

1

(ii) only prevents tRNA binding to 70S / prokaryotic / bacterial ribosomes / human ribosomes are different sizes / shapes / structure;

1

[7]

Q11.

(a) molecule (on cell surface);
that triggers immune response;

2

(b) (i) axes right way round and labelled;
2nd peak drawn higher;
steeper gradient on second rise;

3

(ii) because one dose does not give a high enough level of antibody to be effective / because the antibody falls after a while;

1

(iii) antigens are only single molecules / part of parasite;
do not actually cause disease;

2

(c) malaria sufferers would have parasites in red blood cells;

1

[9]

Q12.

(a) 1. Outside of virus has antigens / proteins;
2. With complementary shape to receptor / protein in membrane of cells;
3. (Receptor / protein) found only on membrane of nerve cells.

Accept converse argument

3

(b) 1. No more (nerve) cells infected / no more cold sores form;
2. (Because) virus is not replicating.

2

(c) Prevents replication of virus.

1

(d) MicroRNA binds to cell's mRNA (no mark)
1. (Binds) by specific base pairing;
2. (So) prevents mRNA being read by ribosomes;
3. (So) prevents translation / production of proteins;
4. (Proteins) that cause cell death.

4

[10]

Q13.

(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 <u>B cells</u> into plasma cells;

3. Plasma cells <u>release</u> antibodies;

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

4

[9]

Q14.

(a) 1. (Anti-AQP4) antibody has a (specific) tertiary structure;
2. Has binding site / variable region that only binds to / complementary to one <u>antigen</u>;
3. Antigen to this antibody (only) found on these nerve cells;
4. So, antibody (only) binds to / forms antigen-antibody complex with these nerve cells (causing damage);

Reject "active site" (only penalise once if it occurs throughout)

3. / 4. Accept 'receptor' for antigen

4

(b) 1. Only 20 in the study;
OR

Only one study;

2. For some concentrations of antibody there is a range in the number of vertebrae surrounding damaged nerve cells;
3. No statistical test used;
4. Correlation is weak;

1. Accept small sample

2. Accept suitable use of data

2. Accept converse

3 max

(c) 1. The monoclonal antibody binds to nerve cell antigen so less / no anti-AQP4 can bind;

OR

The monoclonal antibody forms antigen-antibody complex with nerve cell antigen so less / no anti-AQP4 can bind;

2. When monoclonal antibody binds it doesn't cause damage to nerve cell;

It = monoclonal antibody

1. Reject "active site"

Ignore "competitive inhibitor"

Accept receptor for antigen

Do not credit responses in the context of enzymes

2 max

[9]