AQA A-LEVEL · 7402

BIOLOGY



MARK SCHEME

3.2.4 CELL RECOGNITION AND THE IMMUNE SYSTEM

SCORE	PERCENTAGE
/532	%

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Q1.

(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]

Q2.

(a) 1. (Antivenom/Passive immunity) antibodies bind to the toxin/venom/antigen and (causes) its destruction;

For 'bind' accept 'attach', ignore 'attack'.

For 'destruction of toxin' accept agglutination or phagocytosis.

Ignore reference to antibodies 'neutralising toxin/stopping damage'

Reject reference to 'killing' toxin/venom.

2. Active immunity would be too slow/slower;

Accept 'passive immunity is faster', not simply 'passive immunity is fast'.

2

(b) 1. May be different form of antigen/toxin (within one species)
OR
Snakes (within one species) may have different mutations/alleles;

2. Different antibodies (needed in the antivenom)
OR
(Several) antibodies complementary (to several antigens);

No mark points are available for answers related to collecting venom from different species of snake.

2 max

(c) 1. Horses **because** more antivenom/antibodies could be collected (as more blood collected);

2. 4550 (cm^3) v 26 (cm^3) (blood collected);

Accept 175 rabbits needed to (collect the volume of blood from) one horse.

2

(d) 1. (So) the animal does not suffer from the venom/vaccine/toxin;

2. (So) the animal does not suffer anaemia/does not suffer as a result of blood collection;

3. (So) the animal does not have pathogen that could be transferred to humans;

Accept 'To fulfil licence/legal requirements'.

Accept '(So) the animal does not have pathogen that could result in it producing other antibodies (not wanted in the antivenom)'.

For 'pathogen' accept correct form of pathogen.

1 max

(e) 1. B cells specific to the venom reproduce by mitosis;

Accept in context of primary or secondary immune response.

Credit idea of specificity if given once in relation to T or B cell.

Accept a description for specificity.

Accept 'clone' for 'reproduce by mitosis'.

'Clonal selection of B cells' = MP1.

2. (B cells produce) plasma cells and memory cells;

3. The second dose produces antibodies (in secondary immune response) in higher concentration **and** quickly
OR
The first dose must be small so the animal is not killed;

Accept 'a lot of antibody' for 'higher concentration of antibody'.

3

[10]

Q3.

(a) Correlation coefficient **and** because looking for correlation / relationship / association between two variables / between B cells destroyed and CD20;

Accept Pearson and Spearman

Accept factor for variable

Wrong test or wrong reason = 0 marks

1

(b) 1. The more CD20 (on B cells), higher the percentage of / more B cells destroyed / more effective it is;

Ignore ref. to 'positive correlation' unqualified

Ignore ref. to correlation vs. causation

Ignore ref. to effects on the immune system

2. (At best) only destroys (about) 80% of B cells

OR

In no cases are all B cells killed;

3. Don't know % / proportion of cancer cells killed;

4. Won't cure CLL / cancer / slows but doesn't stop CLL / cancer;

5. Little effect below (about) 5 CD20 on cells;

Ignore ref. to little effect where little CD20

3 max

(c) 1.8×10^{8};;

If correct difference but expressed in non-standard form, award 1 mark;

Award 1 mark if answer given as 1.8×10^{-8}

2

(d) 1. Mutation changes the tertiary structure / amino acid sequence of transcription factor;

Do not accept unqualified statements about non-functional transcription factor – this is in stem of question

Answers must be in context of transcription factor, not CD20, or generic statements

2. Transcription factor not complementary to / cannot bind to CD20 gene / CD20 DNA;

Do not accept unqualified statements about non-functional transcription factor – this is in stem of question

Answers must be in context of transcription factor, not CD20, or generic statements

Accept TF cannot bind to promoter (on DNA)

3. Little / less / not enough / no mRNA for CD20 produced
OR
Little / less / not enough / no (mRNA for) CD20 translated / produced;

4. (Not enough CD20 so) nothing / little for Rituximab to bind to, so few / no B cells destroyed;

Accept converse for cells with a lot of CD20

Accept lower median percentage for fewer cells destroyed

3 max

[9]

Q4.

(a) 1. Person (infected with HIV) has HIV DNA (in their DNA);
2. New HIV (particles) still made;
3. (AZT) inhibits reverse transcriptase;
4. (AZT) stops these (new HIV particles) from forming new HIV DNA;
OR
Slows / stops replication of HIV;
5. Stops destruction of more / newly infected T cells;
6. So immune system continues to work (and AIDS does not develop);

4. Context is important

4. Allow slows / stops (re)production of HIV

4. Reject (AZT) prevents DNA replication

4 max

(b) 1. Slows / stops the development of AIDS;
2. Because HIV **resistant to AZT** is damaged / destroyed / prevented from replicating (by other drugs);
OR
3. AZT continues to work as a drug;
4. Because HAART prevents the spread of AZT-resistant HIV to rest of the human population;
OR
5. No new HIV particles made;
6. Because HAART might interfere with viral protein synthesis;

Mark in pairs.

Do not mix and match.

2. Neutral HIV killed

2. Accept other drugs prevent HIV resistant to AZT from infecting new / more cells

6. Accept blocks transcription / translation / synthesis of lipid envelope / aspect of viral structure

4 max

(c) 1. (Fewer mitochondria so) less (aerobic) respiration;
2. (Muscles receive) less ATP (so waste);

1. Ignore no respiration

2. Reject less energy produced

2. Ignore no ATP is made

2

[10]

Q5.

(a) 1. (Anti-AQP4) antibody has a (specific) tertiary structure;
2. Has binding site / variable region that only binds to / complementary to one antigen;
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]

Q6.

(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]

Q7.

(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]

Q8.

(a) 1. Antigen / epitope on surface of *N. meninigitidis* / bacterium binds to surface protein / surface receptor on a (specific / single) B cell.

If answered in context of T cell, allow Antigen binds to (specific / single) T cell

2. (Activated) B cell divides by mitosis / produces clone;
   If answered in context of T cell, allow (Activated) T cell releases cytokine.

3. (Division) stimulated by cytokines / by T cells;
   If answered in context of T cell, allow (Cytokine) stimulates production of plasma cells;

4. B cells / plasma cells release antibodies;

5. (Some) B cells become memory cells;

6. Memory cells produce plasma / antibodies faster

6

(b) 1. Mutation
   Allow horizontal gene transfer

2. Results in Nm cell with allele for resistance to <u>one</u> antibiotic / to named antibiotic

3. (This) cell survives <u>and</u> passes the allele for resistance to offspring;
   2. and 3. If gene for resistance, penalise once

4. Process repeated with different genes conferring resistance to each of the other (two) antibiotics
   If reference made to 'resistant gene', 2 max for MP2, 3 and 4

4

(c) Any **five** contrasting statements, e.g.

1. Bacterial cell is <u>much</u> smaller than a human cell;

2. Bacterial cell has a cell wall but human cell does not;

3. Bacterial cell lacks a nucleus but human cell has a nucleus;

4. Bacterial cell lacks <u>membrane-bound</u> organelles but human cell has membrane-bound organelles;
   Accept any named membrane-bound organelle

5. Bacterial ribosomes smaller than human ribosomes / bacteria have 70S ribosomes whereas humans have 80S ribosomes;

6. Bacterial DNA is circular but human DNA is linear;

7. Bacterial DNA is 'naked' whereas human DNA is bound to histones / proteins
   Since contrast is required, both parts of each statement must be present to gain the mark.

5 max

[15]

Q9.

(a) 1. Replacement of a base by a different base (in DNA);

1

(b) 1. (Depends on) size / mass (of protein);

2. (Depends on) charge (of protein);

Accept for 2 marks 'Smaller / more highly charged move further'

2 max

(c) 1. Each protein has a different tertiary structure;

2. (Each) antibody has a specific antigen / binding / variable region / site;

3. So, (each antibody) forms different antigen-antibody complex
OR
(each antibody) only binds to complementary (protein);

3

(d) 1. Less NL3;

2. More NR2A **and** NR2B;

2

(e) 1. Higher ratio NR2B to NR2A with mutation;

Accept 'more' as equivalent to 'ratio'

2. (Perhaps) better memory in mice with mutation;

2

[10]

Q10.

(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]

Q11.

(a) 1. Antibody has tertiary structure;
2. Complementary to binding site on protein.

2

(b) 1. Prevents false negative results;
2. (Since) shows antibody **A** has moved up strip / has not bound to any *Plasmodium* protein.

2

(c) 1. Person is infected with *Plasmodium* / has malaria;
2. Infected with (*Plasmodium*) *vivax*;
3. Coloured dye where antibody **C** present;
4. That only binds to protein from *vivax* / no reaction with antibody for *falciparum*.

Person is infected with P. vivax / Plasmodium vivax = 2 marks (MP1 and MP2)

4

[8]

Q12.

(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]

Q13.

(a) (To diagnose AIDS, need to look for / at)
1. (AIDS-related) symptoms;
2. Number of <u>helper</u> T cells.

Neutral: 'only detects HIV antibodies' as given in the question stem

2

(b) 1. HIV antibody is not present;

Accept HIV antibodies will not bind (to antigen)

2. (So) second antibody / enzyme will not bind / is not present.

2

(c) 1. Children receive (HIV) antibodies from their mothers / maternal antibodies;
2. (So) solution will always turn blue / will always test positive (before 18 months).

Allow 1 mark for the suggestion that the child does not produce antibodies yet so test may be negative

2

(d) (Shows that)
1. Only the enzyme / nothing else is causing a colour change;
2. Washing is effective / all unbound antibody is washed away.

2

[8]

Q14.

(a) 1. Rank all STs in ascending order;
2. Find value with same number (of people) above and below.

Accept find middle value

2

(b) Not ethical to fail to treat cancer.

1

(c) Yes since with ipilimumab:

1. Median ST increased by 2.1 months;
2. Percentage of patients showing reduction in tumours increased from 10.3% to 15.2%;

No because:
3. No standard errors shown / no (Student) t- test / no statistical test carried out;
4. (So) not able to tell if differences are (statistically) significant / due to chance (alone);
5. Improvement might only be evident in some patients / no improvement in some patients;
6. Quality of (extra) time alive not reported;

If answers relate only to 'Yes' or ☐No', award 2 marks max

4 max

(d) 1. Faulty protein recognised as an antigen / as a 'foreign' protein;
2. T cells will bind to faulty protein / to (this) 'foreign' protein;
3. (Sensitised) T cells will stimulate clonal selection of B cells;
4. (Resulting in) release of antibodies against faulty protein.

3 max

[10]

Q15.

(a)

Feature	Bacterium	Human immunodeficiency virus (HIV) particle
RNA	✔	✔
Cell wall	✔	
Enzyme molecules	✔	✔
Capsid		✔

1 mark for each correct vertical column

2

(b) 1. (Complementary) nucleotides/bases pair
OR
A to T **and** C to G;

Ignore '(DNA polymerase) forms base pairs/nucleotide pairs'

2. DNA polymerase;
3. Nucleotides join together (to form new strand)/phosphodiester bonds form;

Ignore '(DNA polymerase) forms base pairs/nucleotide pairs'

*If clearly writing rote answer about DNA replication **2 max***
e.g. helicase or separating strands

3

(c) 1. DNA double stranded/double helix **and** mRNA single-stranded;

Contrast requires both parts of the statement

2. DNA (very) long **and** RNA short;

*Accept 'RNA short**er**' or 'DNA bigg**er**/long**er**'*

3. Thymine/T in DNA **and** uracil/U in RNA;
4. Deoxyribose in DNA **and** ribose in RNA;

***R** Deoxyribonucleic/ ribonucleic acid*

***Ignore** ref. to histones*

***Ignore** ref. to helix and straight chain alone*

5. DNA has base pairing **and** mRNA doesn't/ DNA has hydrogen bonding and mRNA doesn't;
6. DNA has introns/non-coding sequences **and** mRNA doesn't;

***Ignore** ref to splicing*

3 max

[8]

Q16.

(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]

Q17.

(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]

Q18.

(a) 1. Antigen stimulates immune response / activates B/T cells;
2. B/T cells divide OR antibodies produced;
3. Antibodies/T cells attack myelin sheaths;

Ignore references to antigen binding to myelin

3

(b) 1. Fewer cristae/smaller surface area (of cristae);

2. So less electron transport/oxidative phosphorylation;
3. (So) not enough ATP produced
OR
Not enough energy to keep neurones alive;

1. Accept 'inner membrane' as 'cristae'

2. Accept fewer ATP synthase enzymes

2. Accept lower rate of electron transfer/oxidative phosphorylation

3. Accept less use/stimulation of neurone leads to death of cell

3. Accept no/less ATP produced/no energy to keep neurones alive

3. Ignore references to glycolysis/ Krebs cycle

3

(c) (i) (Transmission) electron (microscope) – **no mark**

Need high resolution (to see structure of mitochondria)

Accept 'scanning electron microscope' /TEM/SEM

Accept – optical microscope not high enough resolution

1

(ii) 1. Took photographs/areas at random;
2. Counted total number (of normal) and number of unusual mitochondria;
3. Divided number of unusual mitochondria by total number and multiplied by 100;

1. Accept (very) large number of areas/photos/samples

MP 3 = 2 marks (includes MP2)

3

[10]

Q19.

(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]

Q20.

(a) Any **two** from:
1. (Decrease linked to) few(er) cases of whooping cough;
2. (Decrease linked to) risk of / fear of side effects;
3. Insufficient vaccine available / too expensive to produce / distribute.

3. Too expensive unqualified is insufficient for mark

2 max

(b) 1. Vaccination rate increases;
2. Fewer people to spread the disease / whooping cough / more people immune / fewer susceptible.

2. Neutral − greater herd effect

2. Allow description of immune

***Q** Reject 'resistant'.*

2

(c) 1. More people are immune / fewer people carry the pathogen;

If neither point 1 or 2 awarded

Herd immunity = 1 mark

Unvaccinated does not mean infected

*1. **Q** Do not accept disease for pathogen*

2. So susceptible / unvaccinated people less likely to contact infected people.

2

[6]

Q21.

(a) Regulator protein.

Accept regulator protein antigen

Reject regulator protein receptor

Ignore regular protein

1

(b) 1. Lipid soluble / hydrophobic
2. Enters through (phospholipid) bilayer

OR

3. (Protein part of) LDL attaches to <u>receptor</u>
4. Goes through carrier / channel protein.

4. Accept by facilitated diffusion or active transport

4. Reject active transport through channel protein

2

(c) Any **two** from:
1. (Monoclonal antibody) has a specific tertiary structure / variable region / is complementary to regulator protein

Do not award MP1 if reference to active site.

2. Binds to / forms complex with (regulator protein)

"It" refers to monoclonal antibody in MP1 and MP2

3. (So regulator protein) would not fit / bind to the receptor / is not complementary to receptor

3. Reject receptor on LDL

2 max

(d) 1. Injection with salt solution

1. Accept inject placebo in salt solution

2. Otherwise treated the same.

2

[7]

Q22.

(a) (i) 1. (Tumour suppressor) gene inactivated / not able to control / slow down cell division;

Ignore: references to growth

2. Rate of cell division too fast / out of control.

1 and 2 Accept: mitosis

1 and 2 Reject: meiosis

2

(ii) 1. (Genetic) code degenerate;

Accept: codon for triplet

Accept description of degenerate code, e.g. another triplet codes for the same amino acid

2. Mutation in intron.

Accept: mutation in non-coding DNA

1 max

(b) 1. Antibody has specific tertiary structure / binding site / variable region;

Do not accept explanations involving undefined antigen

2. Complementary (shape / fit) to receptor protein / GF / binds to receptor protein / to GF;

Ignore: same shape as receptor protein / GF

3. Prevents GF binding (to receptor).

3

[6]

Q23.

(a) *QWC*

1. (Phagocyte engulfs) to form vacuole / vesicle / phagosome;

Accept surrounds bacteria with membrane

2. Lysosome empties contents into vacuole / vesicle / phagosome;

Accept joins / fuses

3. (Releasing) enzymes that digest / hydrolyse bacteria;

Ignore breakdown / destroy / lytic enzymes

3

(b) Two suitable structures;;

Examples,

1. Cell wall;
2. Capsule / slime layer;
3. Circular DNA;
   Reject "circular chromosome"
4. Naked DNA / DNA without histones;
5. Flagellum;
6. Plasmid;
7. Pilus;
8. 70s / smaller ribosomes;
9. Mesosome;

2 max

[5]

Q24.

(a) (i) **(Whole-cell vaccine),**

Accept converse statements for other vaccine

Reject references to the vaccine being alive or the disease reproducing etc

1. Heat(ing) supposed to kill bacteria;
2. Some might be alive / active / viable;
   Accept active pathogens present
3. (If so) bacteria could reproduce;
4. Bacterium makes or contains toxin;
5. Toxin might not be affected / all destroyed by heat;
6. Bacteria or toxins attacking / killing person's cells;

3 max

(ii) **(Whole-cell vaccine),**

Ignore references to more / greater antigens unqualified. It is the variety of antigens that matters

1. (Contains) many different / greater range of antigens;
2. Each antigen causes its own immune response / production of / has a specific (type of) antibody;

2

(b) 1. Only patients who had whooping cough have toxin / antibody / immune response;

Accept converse e.g. those without antibody had another

disease

2. Toxin is an antigen and is (only) produced by this bacterium;

3. Leading to presence of specific antibody / only 4% had this antibody / 13% did not have antibody;

3

(c) 1. There may not be large rises;

2. Might be the result of wrong diagnosis / reference to difference in figures / 13% diagnosed with whooping cough didn't have it;

Ignore reference to new strains or antigenic variability

2

[10]

Q25.

(a) (i) 1. (Scientists) can't show bias / influence / may have a vested interest / work for the company developing the vaccine;

Relates to the scientists

2. (Volunteers) can't show psychological / mental effects / 'placebo effect' / expectations;

Relates to the volunteers

Accept: reduces the 'Hawthorne effect' / demand characteristics

Neutral: so they have no idea what they are taking

2

(ii) Any **two** suitable suggestions, eg

Neutral: refs. to age and health

1. Amount of nicotine in cigarettes;

Neutral: different types of cigarette / different ways / frequency of smoking

2. Amount inhaled / absorbed / time since last cigarette;

Neutral: absorption by gut / digestion

Accept: absorption by mouth

3. (Different) amounts excreted / metabolism / rate of binding (of nicotine) to protein;

Accept: broken down (differently)

4. (Different) blood volumes;

Neutral: different body masses

5. Nicotine from passive smoking / other smokers / other sources;

6. Some volunteers received the vaccine / placebo;

Accept: some volunteers would have / would not have the antibodies

2 max

(b) (i) 1. Antibodies to nicotine produced / antibodies bind to nicotine;

Q *Reject: vaccine contains / produces antibodies*

Q *Neutral: antibodies digest / kill / fight nicotine*

2. (So) nicotine does not bind to protein / does not reach the brain;

Q *Reject: any reference to 'active site'*

Neutral: idea that the antibodies bind to the protein

3. (So) cigarettes / smoking does not satisfy addiction / reward smokers / release (reward) chemicals;

3

(ii) **(Agree):**

1. People choose to smoke / know the risks;

2. Should spend this money on education / preventing people from starting to smoke / treating other health problems / vaccines are expensive;

(Disagree):

3. Unethical not to treat;

4. Less money needed to treat the effects of smoking / cancer / smokers pay taxes so are entitled to treatment;

3 max

(c) 1. High antibody responders have a high % to stop smoking / are more likely to stop smoking;

'People producing a high concentration of antibodies' is equivalent to 'high antibody responders'

Accept: reference to values from the table

2. Only a few may be high antibody responders / no numbers on how many are high / medium / low antibody responders;

Neutral: not all people are high antibody responders

3. Percentage who stopped smoking is similar for placebo group and low / medium responders / some / % of placebo group (still) stopped smoking / placebo has the lowest value / % to stop smoking;

Accept: reference to values from the table

4. Large sample size / double blind **so** reliable / representative;

5. Antibody levels peak at / drop after <u>5 months</u> / boosters may be needed at / after 5 months;

6. May start smoking again after 5 / 6 months / do not know the percentage who stopped smoking after 5 / 6 months;

7. <u>Nicotine</u> is not the only factor responsible for making people smoke;

Must mention nicotine

Do not accept: correlation does not mean causation / could be due to other factors

5 max

[15]

Q26.

(a) (i) Substance that causes an immune response / production of antibodies;

Ignore foreign / non-self

1

(ii) 1. Not lipid soluble;

2. Too large (to diffuse through the membrane);

3. Antigens do not have the complementary shape / cannot bind to receptor / channel / carrier proteins (in membranes of other epithelial cells);

2 max

(b) 1. (Vaccine contains) antigen / attenuated / dead pathogen;

1. Reject if in context of injection of vaccine

2. T-cells activate B-cells;

3. B-cells divide / form clone / undergo mitosis;

4. Plasma cells produce antibodies;

5. Memory cells produced meaning more antibodies / antibodies produced faster in secondary response / on reinfection;

5

[8]

Q27.

(a) 1. Infected by / susceptible to (other) pathogen(s) / named disease caused by a pathogen (from environment);

Context is where immune system cannot prevent or stop these events

Allow attack / kill

2. Pathogen(s) reproduce / cause diease (in host);

MPs not given in context of HIV

3. Damage cells / tissues / organs;

4. Release toxins;

3 max

(b) (i) 1. (HIV enters cells) before antibodies can bind to / destroy it;

Ignore SAFETY comments

1. and 2. Relate to antibodies

2. Antibodies cannot enter cells (to destroy HIV) / stay in blood;

OR

3. (Enters cells) before (secondary) immune response caused /

before memory cells have time to respond;
3. and 4. Relate to virus

4. So no antibodies present (to attack HIV);

OR

5. Vaccine taken up too quickly to cause immune response;
5. and 6. Relate to vaccine

6. So no antibodies / memory cells formed;

2 max

(ii) 1. Antigen (on HIV) changes;
Accept mutates

2. (Specific) antibody / receptor no longer binds to (new) antigen;
Ignore SAFETY comments

OR

3. Many different strains of HIV / many antigens present on HIV;

4. Not possible to make a vaccine for all antigens / vaccine may not stimulate an antibody for a particular antigen;

2 max

(c) 3 suitable suggestions;;;
QWC ignore reference to HIV cells

E.g.

1. Inactive virus may become active / viral transformation;

2. Attenuated virus might become harmful;

3. Non-pathogenic virus may mutate and harm cells;

4. Genetic information / protein (from HIV) may harm cells;

5. People (may) become / test HIV positive after vaccine used;
Vaccinated people may develop disease from a different strain to that in the vaccine

6. This may affect their work / life;
May continue high risk activities and develop or pass on HIV

3 max

[10]

Q28.

(a) (Micro)organism that causes disease / harm to body / an immune response;
Accept: named microorganism that causes disease
Allow infection

1

(b) 1. Phagocyte attracted by a substance / recognises (foreign) antigen;
Accept named substance eg chemical / antigen

2. (Pathogen)engulfed / ingested;
Accept: description

3. Enclosed in vacuole / vesicle / phagosome;

4. (Vacuole) fuses / joins with lysosome;

5. Lysosome contains enzymes;
Accept named example of enzyme

6. Pathogen digested / molecules hydrolysed;
Neutral: Destroyed

4 max

(c) 1. Antigens (on pathogen) are a specific shape / have specific tertiary / 3D structure;
1 / 3 Structure alone is insufficient

2. Antibody fits / binds / is complementary to antigen / antibody-antigen complex forms;
Reject - active site

OR

3. Antibodies are a specific shape / have specific tertiary / 3D structure;

4. Antigens (on pathogen) fit / bind / are complementary to antibody / antibody-antigen complex forms;

2

[7]

Q29.

(a) Hydrolysis (reaction);
Accept phonetic spelling

1

(b) 1. Too big / wrong shape;
Wrong charge - neutral
Accept insoluble

2. To fit / bind / pass through (membrane / into cell / through carrier / channel protein);

3. Carrier / channel protein;
Accept carrier / channel protein not present

3

(c) Foreign / (act as) antigen / non-self;
Reject foreign cells

1

(d) 1. Dose to be given;

Accept: interaction with other drugs

2. No (serious) side effects;

3. How effective;

4. Cost of drug;

2 max

[7]

Q30.

(a) Has more than one / four polypeptide chains / made up of polypeptide chains;

1

(b) 1. Antibody / variable region has specific amino acid sequence / primary structure;

2. The shape / tertiary structure of the binding site is complementary to / fits / binds with these antigens;

2. Do not accept active site for this point.

3. Forms complex between antigen and antibody;

3

[4]

Q31.

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. Rapidly produce antibodies / produces more 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]

Q32.

(a) Nitrification;

Accept nitrifying.

Do not accept nitrogen fixing.

1

(b) 1. Uptake (by roots) involves active transport;

Reject all references to bacteria

2. Requires ATP / aerobic respiration;

2

(c) (i) 1. Not enough time / fast flow washes bacteria away;
"Not enough time for bacteria to convert all the ammonia to nitrate" gains 2 marks

2. (Not all / less) ammonia converted to nitrate / less nitrification;

2

(ii) 1. Algal bloom / increase in algae blocks light / plants / algae die;

2. Decomposers / saprobionts / bacteria break down dead plant materials;

3. Bacteria / decomposers / saprobionts use up oxygen in respiration / increase BOD causing fish to die;
3. Accept alternatives such as microbes / saprophytes.

3

[8]

Q33.

(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]

Q34.

(a) 1. Phagocyte attracted to bacteria by chemicals / recognise antigens on bacteria as foreign;

2. Engulf / ingest bacteria;

3. Bacteria in vacuole / vesicle;

4. Lysosome fuses with / empties enzymes into vacuole;

5. Bacteria digested / hydrolysed;

1. Accept names chemical e.g. toxin

2. Allow description of engulfing

3. Accept: bacteria in phagosome

5. Neutral: Break down

5. Accept digestive enzymes destroy bacteria

5. Do not accept ''destroy bacteria'' as it is in question stem

4 max

(b) 1. Microvilli provide a large / increased surface area;

2. Many mitochondria produce ATP / release or provide energy (for active transport);

3. Carrier proteins for active transport;

4. Channel / carrier proteins for facilitated diffusion;

5. Co-transport of sodium (ions) and glucose or symport / carrier protein for sodium (ions) and glucose;

6. Membrane-bound enzymes digest disaccharides / produce glucose;

1. Reject villi on epithelial cells

1. Accept brush border

2. Accept large SA:vol ratio

3. Need idea of ''lots''

4. Reject: energy produced

5. Accept Na^+K^+ pump

6. Neutral: Channel proteins

7. Accept named example

6

[10]

Q35.

(a) (i) Antibiotics kill other bacteria / *Clostridium* is resistant;

Less / no competition so (*Clostridium*)
reproduces / replicates / multiplies / increases in number;

Reference to bacteria being 'immune' negates first marking point.

Reference to mitosis negates second marking point.

2

(ii) Immune system less effective / more likely to have other infections / been in hospital;

Accept: 'Weak / lower' immune system'.

1

(b) Attaches to <u>active</u> <u>site</u> (of enzyme);
(Methicillin) is a competitive inhibitor / prevents monomers / substrate attaching (to enzyme);

'Competes for active site' = 2 marks.

Neutral: 'Prevents monomers joining / attaching to each other'.

Allow one mark max for answers relating to non-competitive inhibitor changing active site / preventing substrate attaching.

Do not penalise Methicillin forms an enzyme / substrate complex.

2

(c) (i) Have other illness / medical condition / 'weak' immune system / disease / infection;

Reject: Due to 'other factors', 'are smokers', 'are obese' unless related to disease or illness.

1

(ii) Increase up to 2006 / 20 (per 100 000) then decreases;

1

(iii) Correct answer in range of 52 – 59.1% = two marks;

Incorrect answer but shows change as between 4.8 – 5.2 / shows correct subtraction giving this change e.g. 14 – 9 = one mark.

2

[9]

Q36.

(a) Straight lines point to point as not possible to predict intermediate values / values between points;

1

(b) Increases then levels / falls;
Maximum antibody production 180 units / at dose of 0.25 g per kg;

2

(c) Two marks for correct answer of 57.14 / 57.1;;
One mark for incorrect answer in which candidate clearly divides difference in antibody production / 60 by 105;

2

(d) Takes into account different masses of mice / allows comparison;

Accept different weights of mice.
Do not accept different size.

1

(e) Sheep red blood cells have antigens (on their surface);
Antigens are proteins foreign to mice / are non-self;
Stimulate B cells to produce antibodies;

3

(f) Response only observed in mice;
Disease organisms not investigated;
Not all disease caused by pathogens / cured by antibodies;
i.e. not tested on humans

2 max

[11]

Q37.

(a) (i) To show whether immune response occured / because cats are (genetically) related to cheetahs;
Ignore reference to control.

1

(ii) To show that rejection did not normally occur / skin could (successfully) be grafted;

1

(b) (i) Rapid rejection between unrelated (domestic) cats / cats are **not** genetically similar;
Rapid rejection between (domestic) cat and cheetah / cats and cheetahs are not genetically similar;
Slow / no rejection in cheetahs / cheetahs are genetically similar;

3

(ii) Sample size small;
Time observed was short;

1 max

(iii) Similar (antigens on all cheetahs);
Accept same / not very different

1

(iv) Protein / antigen production determined by alleles / genes / base sequence on DNA;
The more similar the proteins the more similar their alleles / genes / base sequence on DNA / the more they are genetically similar;

2

[9]

Q38.

(a) Girls are not sexually active / not likely to carry HPV / vaccine may not work if already infected / few girls sexually active (at this age);
Neutral: girls are not sexually mature
Neutral: to provide better protection
Accept: provides immunity before sexually active
*Neutral: girls are less likely to have '**it**' as could mean the*

vaccine from the question stem

1

(b) Other (HPV) types have different antigens;

No memory cells for other types / memory cells not activated / antibodies cannot attach to antigen / correct antibodies not produced / antibodies are not complementary;

Accept: refs. to antigenic variability

Accept: B cells for memory cells

Accept: memory cells cannot recognise antigen for 'not activated'

Accept: examples of memory cell activation

2

(c) More antigen;

More memory cells;

So more antibodies produced / antibodies produced quicker (if infected);

Accept: 'many' / 'enough' instead of 'more'

Neutral: primary / secondary response

Accept: T cells / B cells / plasma cells instead of 'antibodies'

Reject: the idea that vaccines contain antibodies

***Q** Reject: antibodies 'fight' / 'antibiotics'*

2 max

(d) Cancer takes years to develop / develops later in life;

Takes time for females to become sexually active / females must become sexually active to obtain data;

Few people / only teenagers vaccinated;

Neutral: will take time to vaccinate 80% of young girls

Accept: do not develop cancer instantly

2 max

(e) (Cervical cancer) can be caused by other types of HPV / other factors / example given;

OR

(Some) women may have been infected (with HPV) before receiving the vaccine;

OR

(As a precaution) in case vaccine does not work / a way of monitoring if the vaccine has worked;

Accept: 'caused by other types of HPV' in the context of mutation

Neutral: to check for abnormal cells / that they are immune to the virus

1

(f) Virus cannot replicate / is destroyed / is not carried (in vaccinated people);

Non-vaccinated people more likely to contact vaccinated people;

Neutral: 'do not spread virus' as in question stem

Must be in context of the individual and not the population as in question stem

***Q** Do not allow 'disease is destroyed'*

Neutral: 'herd effect' as given in the question stem

2

[10]

Q39.

(a) (yes):
Many women (with cervical cancer) have HPV 16 (18 &31);

(no):
Few women (with cervical cancer) have HPV 6 / 11;

(HPV infection does not mean causation because):
Could be caused by another factor / example given / may be due to coincidence;

No control group / did not study HPV in healthy women / did not study all HPV types / having cancer may increase susceptibility to HPV / does not add up to 100% / not all women with cancer have HPV / individual may have more than one HPV type;

Neutral: correlation between HPV (16) and cervical cancer

Reject: many women with HPV 16 (18 &31) have cervical cancer / not all women have cancer

Accept: figures from graph for 'many' and 'few'

Accept: minor errors in reading HPV frequencies from graph

Reject: does not mean HPV vaccine causes cancer;

Neutral: refs. to sample size and factors that should have been kept constant

3 max

(b) (i) Protein / glycoprotein / glycolipid / polysaccharide;

Causes immune response / antibody production;

Accept: B / T cell production

2

(ii) Memory cells produced / remain / stored (from previous infection);

Neutral: antibodies produced / remain

(When individual) comes into contact with virus / antigen (again);

Neutral: 'cell' instead of 'virus'
Reject: 'bacteria' once only

Rapid / secondary / greater response / many or more antibodies produced;

Accept: B cells / T cells

Destroys virus / antigen before it can cause harm / symptoms / cancer;

Reject: if destroys the virus / antigen in the vaccine before it

can cause harm

***Q** Do not allow 'fights HPV'*

***Q** Do not allow 'memory cells remember'*

3 max

(c) HPV destroyed in males / prevents males being carriers of HPV;

Neutral: prevents males catching HPV

Prevents males passing on HPV (to unvaccinated females) / HPV may cause (other) cancers in males;

Accept: reference to herd effect protecting the population

2

[10]

Q40.

(a) Virus / fungus / protozoan;

Neutral: named example

1

(b) Produces toxins;

Neutral: infects / colonises / invades cells

Damages cells / tissues / example given e.g. cell lysis;

2

(c) (i) (Antibodies) produced from a single clone of B cells / plasma cells;

Accept: hybridoma cell line instead of B cell / plasma cell
Reject: idea that antibodies are cloned

OR

(Antibodies) produced from the same B cell / plasma cell;

1

(ii) (Specific) primary structure / order of amino acids;

(Specific) tertiary / 3D structure;

(So) Only binds to / fits / complementary to one antigen;

Reject: 'active site' for either point 2. or 3. only once

3

(d) (Rapid) treatment of carriers / infected cattle / disease;

Neutral: reference to rapid identification of infected cattle

Can isolate / cull carriers / infected cattle / infected (dairy) products not sold / consumed / tracked;

Reduces spread of disease / no need to kill / prevents the death of non-infected animals;

Neutral: ethical arguments

3

[10]

Q41.

(a) Damage / destruction of cells / tissues;
Production of toxins;

2

(b) Contains antigen / proteins / dead / weakened microorganism / pathogen / virus / bacteria;
Stimulates production of antibodies / plasma cells / memory cells;

Q *Do not credit immune response unless qualified.*

2

(c) (i) Age;

Sex;

Ethnicity;

All healthy / not on other medication;

Not previously vaccinated / infected with TB;

Q *Do not credit sample size.*

Q *Allow any suitable reference to health not being affected for fourth marking point e.g. smoking, 'depressed immune system' etc.*

2 max

(ii) Contain the same antigens;

1

[7]

Q42.

(a) Nucleus;

1

(b) Enables organism to remain in area (of food source) / prevent its removal;

Q *'To attach' is not sufficient unless qualified*

1

(c) (i) Correct answer of 222(%);;

Incorrect answer that clearly identifies difference in number of cases as 5800 –1800 or 5.8 – 1.8;

Correct answer gains two marks

2

(ii) More water-related activities / more 'organisms' with increased temperature;

Q *Allow any reference to growth or replication of 'organisms'. Do not penalise reference to bacteria.*

Q *Do not allow increase in water consumption.*

1

(d) (i) All have same shape / only binds to *Giardia* / one type of / specific antigen;

1

(ii) Has complementary (shape) / due to (specific) tertiary structure / variable region (of antibody);

Q *Binds / fits not sufficient unless qualified;*

1

(iii) Enzyme / second antibody would remain / is removed by washing;

Enzyme can react with substrate (when no antigen is present);

2

[9]

Q43.

(a) Phagocytes engulf / ingest pathogens / microorganisms / bacteria / viruses;

Phagocytes destroy pathogens / microorganisms / bacteria / viruses;

Lung diseases are caused by pathogens / microorganisms / bacteria / viruses;

Q *Allow description of process of engulfing*

2 max

(b) (i) Alveoli / lungs will not inflate / deflate fully / reduced lung capacity;

Breathing out particularly affected / no longer passive;

2

(ii) Alveolar walls thicken;

Longer diffusion pathway;

Scarred / fibrous tissue;

Reduces surface area (for gaseous exchange);

Q *Diffusion is essential for 2nd point and surface area for 4th point.*

4

(c) (i) Cancer develops 20 – 30 years after exposure (to asbestos);

1

(ii) Smoking / air pollution / specified industrial source;

1

[10]

Q44.

(a) Phagocytes engulf pathogens / microorganisms;

Enclosed in a vacuole / vesicle / phagosome;

Lysosomes have enzymes;

That digest / hydrolyse molecules / proteins / lipids / microorganism;

3 max

(b) (i) Get another strain / there are different strains;

Therefore does not have memory cells against second strain;

Q *The second marking point should only be awarded in the context of memory cells.*

2

(ii) Vaccines only work against certain strains because the antigens they possess are different;

Enables company to target strain likely to be prevalent later / most common strain;

2

[7]

Q45.

(a) (i) Many people do not go to the doctor;

1

(ii) 36000;

No marks awarded for working here as calculation is very straightforward

1

(b) Same sugars / antigens on bacteria / nerve cells;

Do not accept references to same shape as equivalent to complementary.

Bind with antibody / form antigen-antibody complex;

Reject react

Have complementary shape / fit binding site;

Reject active site

3

(c) Diaphragm will not move down / flatten / contract;

Ignore references to breathing out

Thoracic cavity / lung volume not increased so cannot breathe in;

2

[7]

Q46.

(a) divide by mitosis / form clones;
produce plasma cells;
(plasma cells) make antibodies;
(plasma cells) produce memory cells;

4

(b) glycoprotein;
different shape to body proteins / body phospholipids are the same / located on the outside of the cell / the haemoglobin is located inside the cell;

2

[6]

Q47.

(a) molecule / part of molecule / protein / glycoprotein / named molecule; that stimulates an immune response / eq;

2

(b) divide by mitosis / form clones; produce plasma cells; (plasma cells) make antibodies;
(plasma cells) produce memory cells;

4

(c) (i) glycoprotein AND
different shape to body proteins / RNA and reverse transcriptase inside virus / phospholipids same as body's / on the surface of the virus;

1

(ii) 187.5;;
Accept 187 – 188
1 mark for HIV = 80nm;

2 max

[9]

Q48.

(a) Injection of antigens / toxoids;

(Antigen from) attenuated microorganism / non-virulent microorganisms / dead

microorganisms / isolated from microorganism;

Stimulates the formation of memory cells;

max 2

(b) (i) Antibodies are specific to mumps antigen;
2nd antibodies specific to mumps antibody;

1

(ii) Removes unbound 2nd antibodies;
Otherwise enzyme may be present / may get colour change anyway / false positive;

2

(iii) No antibodies to bind (to antigen);
Therefore 2nd antibody (with the enzyme) won't bind / no enzyme / enzyme-carrying antibody present
(after washing in step 4);

2

[7]

Q49.

(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]

Q50.

(a) add antibodies / enzyme;
wash to remove unbound antibodies;
add (colourless) solution;

(mark correct responses sequentially)

3

(b) antibodies specific / shape only fits one antigen;
other antigens different shape and would not bind to antibodies;

2

[5]

Q51.

(a) (i) protein / immunoglobulin;
specific to antigen;
idea of 'fit' / complementary <u>shape</u>;

2 max

(ii) 1. virus contains antigen;
2. virus engulfed by phagocyte / macrophage;
3. presents antigen to B-cell;
4. memory cells / B-cell becomes activated;
5. (divides to) form clones;
6. by mitosis;
7. plasma cells produce antibodies;
8. antibodies specific to antigen;
9. correct reference to T-cells / cytokines;

6 max

(b) 1. antibody gene located using gene probe;
2. cut using restriction enzyme;
3. at specific base pairs;
4. leaving sticky ends / unpaired bases;
5. cut maize / DNA / vector using same restriction enzyme;
6. join using DNA ligase;
7. introduce vector into maize / crop / recombinant DNA into maize;

4 max

(c) passive / person is not making own antibodies / antibodies not replaced;
memory cells not produced;

2

(d) fewer ethical difficulties / less risk of infection;

1

[15]

Q52.

(a) To prevent contamination of apparatus with other microorganisms / bacteria;
To prevent personal contact with bacteria;
To prevent release of bacteria into air;

max 2

(b) (i) Diffuses slowly;

1

(ii) B;
Produces inhibition zone greater than the minimum diameter;

2

[5]

Q53.

(a) Publicity about vaccination / better health education / risks of 'flu epidemics;
(Accept: now free on NHS (though only since 2000) / better awareness / more commonly available)

1

(b) (i) 1990: 26% of 7.4million = 1.92million *and* 2000: 64% of 7.8 million = 4.99million;
increase = 3.07 million;

2

(Correct reading of all 4 figures from graph = 1)
(Correct answer but no 'millions' = 1)
(Correct method resulting from wrong graph reading = 1)

(ii) Over 50% of population being vaccinated;
But only from 2000 onwards;
(Principle of more people being vaccinated each year = 1)

2

(iii) Different strain / type of virus each year / virus mutates;
With different antigens;
Influenza antibodies / memory cells (rapidly) destroyed / need replacing;

max 2

(c) (Protein coat) carries antigens which stimulates B-cells / production of antibodies;
Production of memory cells;

2

[9]

Q54.

(a) (i) protein / glycoprotein / glycolipid / polysaccharide / molecule;
on surface / membrane (of cell);
causes immune response / description / triggers antibody production;

max 2

(ii) reference to hybrid cell from tumour / cancer and B-lymphocyte / hybridoma;
antibodies all the same / from one type of plasma cell;
specific to / complementary to / fits only one antigen;

max 2

(b) (i) antibodies specific / only binds to PSA;
PSA only associated with prostate cancer / not with other diseases;

2

(ii) antibody with enzyme only attaches if PSA present / washed away if no PSA;
no colour change without enzyme;

2

[8]

Q55.

(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]

Q56.

(a) Presence of resistant and non-resistant varieties / mutation produces resistant variety;
Resistant ones survive / non-resistant ones killed by treatment;
These will reproduce and produce more resistant parasites / pass on resistance allele;

3

(b) Likelihood of being infected (by strain resistant to both drugs) is less;
1/500 × 1/500/1/250 000;
Drug has longer effective life;

max 2

(c) (i) As comparison / to show that nothing else in the treatment was responsible;

1

(ii) Given injections of saline / injection without SPf66;
(otherwise) treated the same as experimental group;

2

(d) (i) 100%;

1

(ii) 10%;

1

(e) (i) Different lengths of DNA have different base sequences / cut at specific sequence;
Results in different shape / different shape of active site;
Therefore (specific sequence) will only fit active site of enzyme;

3

(ii) Recognition sites contain only AT pairs;
Which would occur very frequently;

2

[15]

Q57.

(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 <u>amino acids</u> 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 <u>ribosomes</u> / human <u>ribosomes</u> are different sizes / shapes / structure;

1

[7]

Q58.

(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 <u>mitosis</u> / (B) lymphocytes <u>cloned</u>;
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) <u>gene</u> to <u>plasmid</u>;
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]

Q59.

(a) bacteria have ligands / antigens / proteins / glycoproteins / polysaccharides (on membrane / wall);

1

complementary to receptors / fits / binds / attaches to specific receptor

1

(b) enzymes denatured / tertiary / secondary structure altered / altered active sites / breaks hydrogen bonds;

1

prevents named chemical reactions / metabolic pathways;

1

(c) inhibits / kills other bacteria / fungi / decomposers / reduces competition;

1

(d) 1 prepare a bacterial lawn / culture / sample;
(accept mix bacteria with agar / medium)
2 with oil and one with control / water / range of concentrations;
3 appropriate method of standardising how sample applied, e.g. discs / wells;
4 appropriate measure of effectiveness / size / diameter of clear zone;
5 the larger the zone the greater the effectiveness;
6 use of aseptic technique;
(ignore haemocytometer)

4 max

[9]

Q60.

(i) 1360 = 2 marks
(general principle 0.68 ÷ 0.05 x 100 gains 1 mark)

2

(ii) still have maternal antibodies;

1

[3]

Q61.

(a) (i) fall in deaths due to rise in number of people with immunity / better care / targeting vaccination at vulnerable;

1

(ii) mutation of virus / new strain;
mutant form not recognised by memory cells (*allow antibodies*);

2 max

(b) (i) T lymphocyte receptors recognise shape of haemagglutinin /

neuraminidase / viral antigen;
clone (*once only*);
destroy virus;

2 max

(ii) clone (*once only*);
produce antibodies;
effect of antibody e.g. stimulation of phagocytosis / precipitation of toxins;

2

(c) alter shape of active site of neuraminidase / block active site;
virus unable to leave host cells;

2

[9]

Q62.

(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]

Q63.

(a) 47 213;

1

(b) (i) there is no difference in the proportion / number of influenza cases between the 5 vaccines;
(reject vaccinated versus no vaccinated)

1

(ii) significant difference in proportion / number of cases of influenza between the vaccines / the null hypothesis should be rejected;

1

(c) sample size small;
possible differences in exposure to infection;
exposure to different strains / mutants;
possible differences in existing immunity;
possible differences in sex / age;
possible differences in socio-economic status;

2 max

[5]

Q1.

Generally, the comprehension was far better answered than in 2017. This may be partly due to the specification content included this year compared with last. The main issue, as with last year, is that students attempted to answer the question without using the passage. However, these are true comprehension questions. This was the main issue with question (a), though 70.7% of students did score at least one mark. Many students appreciated that the presence of an antigen caused the production of more T cells which resulted in increased amounts of cytokines being produced. Other students appreciated the former but attributed the swelling to the accumulation of T cells. There were some spurious arguments based on alteration of water potential resulting in accumulation of water, and hence swelling.

(b) was similarly well answered, but those students who failed to score (28.8%) gave vague responses, such as ‘it is passed on’ and also thought that those with Crohn’s disease had genes to make bacteria pathogenic instead of normal.

(c) was poorly answered, with nearly 80% scoring zero marks. Students failed to get from the passage that 5-ASA is a drug that reduces swelling. Incorrect answers centred round “the body seeing the drug as foreign”, “being immune to the drug”, “making antibodies against the drug”, “digesting the drug”, “having no receptors for the drug” or, as 5-ASA is an acid, it “denaturing protein/cytokines”. A significant number of students attempted to relate their argument to an allergy to the drug, but many expressed this in terms of suffering side-effects.

(d) was better answered, with the majority of students able to follow the idea that DNA replication will slow, meaning fewer T cells and less cytokine. The question gave guidance not to include details of enzyme inhibition or protein synthesis. This was to help guide students to the correct answer; many based their arguments on a failure to form enzyme-substrate complexes, despite the advice. There was some confusion of cytokine and cytosine, and some students thought that 6-MP would have stopped bacteria or “Crohn’s” reproducing, not T cells.

Q2.

This question was all based on section 3.2.4 of the specification, in the novel context of production of snake antivenom.

There were two parts to question (a) – how does an antibody work and what is the difference between passive and active immunity? 28.1% of students could answer both of these correctly. Confusion was demonstrated between antigens on a toxin and antibody binding to a pathogen. Errors resulting in the first marking point not being awarded included describing binding, but failing to discuss destruction, or discussing destruction without reference to binding. Commonly, students used the idea of ‘complementary’ in place of binding. Those who were not awarded marking point two tended not to make a comparative statement about active and passive immunity, and some made vague statements about active immunity ‘taking time’, rather than expressing length of time. A mark of zero was commonly the result of confusing active and passive immunity or treating the antivenom as a vaccine which would then trigger an immune response.

In (b), many students gave answers relating to not needing to identify the species of snake that had bitten a person, as the antivenom would work against the venom of several species – this was not creditworthy as the question is clearly related to several snakes of the *same* species. A pleasing number of students understood the production of

antivenom and appreciated the need for several antibodies to be produced by the animal to be used in the patient. Some suggested that one antibody could be effective against several antigens; this was not given credit. Pleasingly, few students confused antigens and antibodies. Common errors included referring to different forms of venom, which was indicated in the question stem, or failing to include reference to antibodies and instead making vague statements about “being effective against” or “fighting off” or “neutralising/counteracting” the venom. Roughly even proportions of students scored two, one and zero marks for this question.

In question (c), most students could complete the required calculation. Even so, many students suggested the rabbit would be better as it would likely be safer for the rabbit as less blood was removed or suggested that the same number of antibodies would be produced in a smaller volume of blood. Of those who did pick the horse, many only stated that more blood could be collected, rather than linking this to more antibodies/antivenom being collected from each animal. 81% of students scored at least one mark here.

Too many generalised answers were given to question (d). At this level, a specific reason why it would be ethical to have veterinary supervision in this particular procedure was required. Confusion was sometimes demonstrated here over whether the animals were being administered venom or antivenom.

In (e), very few students could give a complete account of the humoral immune response in this context, but those who could (7.3%) gave some excellent answers. It was rare to see the idea of specificity to the venom antigens being key to the B-cells cloning, and confusion was demonstrated between T-cells and B-cells and which produced antibodies. About half of the students achieved the second marking point for recognising the two differentiated forms of B-cells, but beyond this many did not achieve any further marks due to vague statements or misconceptions. A small number of students demonstrated a more detailed understanding but still did not obtain marks due to key ideas being missed. Examples included the idea of specificity of T/B-cells missing from their answer for marking point 1, mitosis/cloning missing from marking point 2, or one of the ideas of high concentration or ‘quickly’ missing from marking point 3.

Q3.

Question (a) related to the figure, a scatter graph. 41% of students correctly suggested some form of correlation coefficient and the reason that some form of correlation between two variables was being considered. The question discriminated well.

Question (b) started with an instruction to consider the data in the figure. This question tested AO3, the ability to draw conclusions from information and data provided. The data concern the use of Rituximab to treat CLL, a ‘real life’ context. Many students (57%) obtained onemark, usually for noting that the more CD20 on B cells, the more B cells Rituximab destroys. A further 28% obtained two marks, usually for either noting that in no case are all B cells killed, or that the data do not show the proportion of cancerous and normal B cells killed. Only 5% of students made both points to score three marks. Very few students noted that Rituximab cannot cure CLL. There was a mark available for noting that Rituximab has little effect below 5 arbitrary units of CD20, but few students accurately noted this point in the trend of the data. Many students who failed to score simply described the data, quite often point to point. Others drifted away from these data and speculated on the possible lethal effects of damage to the immune system by Rituximab, meaning that it should not be used. This question was based on a treatment that is used, for a real cancer. Students should assume that doctors and scientists follow proper, ethical scientific and medical procedures and do not set out to kill patients.

In question (c), 54% of students calculated the correct difference and expressed it in standard form. One mark was obtained by 6% of students who calculated the correct

difference but did not put it into standard form. The question discriminated well.

Question (d) discriminated very well. One mark was obtained by 20% of students, usually for either deducing that less CD20 would be produced in people with the *NOTCH1* mutation, or that there would be little for Rituximab to bind to and so few B cells destroyed. 24% of students obtained two marks, usually by making both linked points. Some obtained two marks by noting that the mutation would lead to a change in the tertiary structure of the transcription factor, leading to it not binding to the gene for CD20. Some 14% of students gave the whole story and obtained all three marks. This left 20% who failed to score. Many appeared not to know what a transcription factor is and often wrongly suggested that the mutation would affect the gene for CD20, or the structure of CD20, making it the wrong shape to bind to Rituximab.

Q4.

The whole of question 10 proved to be very challenging for students. This question is a test of comprehension: students must use the passage to be able to answer the questions. Some clearly tried to respond without reading the passage and scored poorly. The mean score on each question part was less than one.

In answers to question (a), there was a clear lack of understanding of the mechanism of HIV infection. Common mistakes included stating that HIV is a bacterium, stating HIV is killed, stating there is no cure for HIV, stating HIV binds to reverse transcriptase, only discussing the action of enzyme inhibition, or simply repeating phrases from the passage. Only 1.4% of students scored four marks, with 45% scoring zero marks.

In answers to question (b) the lack of understanding of the mode of infection and of how the immune system responds was evident. Common mistakes included stating the body or virus becomes immune to AZT, that HIV becomes AIDS, that HAART prevents HIV becoming resistant to AZT and that there would be no need for new antibiotics. Students also tried to include the idea that lower doses of AZT could be taken to prevent muscle wastage, but the passage already stated that AZT is taken in low doses because it causes muscle wasting. Only 0.2% of students scored four marks, with 49% scoring zero marks.

(c) was a simpler question, especially mark point one, but students mostly failed to address the question. Common mistakes included stating less energy is **produced**, less energy **for** respiration, **no** respiration and **no** ATP. Some thought oxygen is released during respiration; there was confusion with protein synthesis, and reverse transcriptase and some simply stated the role of mitochondria. As a result, only 9% of students scored two marks, and 58% scored zero marks.

Q5.

Many students had difficulty assimilating the information given in question (a) and assumed that NMO was a pathogen. This led them to give an extended answer involving the immune response, plasma cells and antibody production. There was also confusion between enzymes and antibodies with many references to active sites and enzyme-substrate complexes. However, almost 40% of the students scored at least 2 marks with some using scientific terminology accurately and writing concise answers which clearly explained how the specific tertiary structure of the variable region of the antibody would be complementary to only one antigen, in this case the antigen on the nerve cell.

Few students gained the 3 marks available for question (b). Most seemed to give just one point and re-state this in several ways; typically this would be relating to the varying number of vertebrae surrounding damaged nerve cells at a particular concentration of antibody. It was not uncommon for students to recognise that the correlation was weak but surprisingly few commented on the small number in the study.

In question (c), as in (a), many students wrote about NMO as a pathogen, or active sites on the antibodies, preventing them from gaining marks. This was a demanding question but there were some excellent answers seen recognising that when the monoclonal antibody binds to the nerve cell antigen it would not cause any damage and it would also prevent anti-AQP4 binding and causing damage. Weaker answers often stated incorrectly that as the variable regions of the two antibodies were the same they would bind together.

Q6.

Both questions (a) and (b) were about specific events within the immune response; many students gave lengthy answers, only small parts of which were relevant to the specific question asked. Some forgot that these two questions were about viruses and started to write about bacteria. Having said this, there were some extremely good answers to both questions, with over half of students achieving at least 2 marks for each.

(a) Many students did not refer to the antigen being presented on the surface membrane of the phagocyte, so could not be awarded mark point 3.

(b) Some students described, once again, how the virus would be presented. Mark points 3 and 4 were more often awarded than mark points 1 and 2, suggesting better understanding of the actions of B cells in the immune response than T cell involvement. Mark point 1 could be awarded if the student stated that a T cell binds to the antigen and then differentiates into a T helper cell.

(c) The responses to this question revealed much misunderstanding of the immune response as a whole, with many references to ‘thinking’ immune systems. Many students simply repeated phrases from the question stem; for example, “since the virus protein and the human collagen have a similar shape, the immune system will attack the human collagen”. Students needed to identify that the part of the immune response which would ‘attack’ the collagen would be the binding of specific antibodies, and then to use their knowledge of how an antigen-antibody complex leads to the destruction of the antigen (section 3.2.4 of the specification), i.e., human collagen in this case. Credit could be gained for reference to agglutination or phagocytosis as methods of ‘attacking’ the human collagen, since these are the methods of antigen destruction named in the specification.

Q15.

The factual recall question, (a), proved far more challenging than intended. Only 5% of students obtained both marks and 54% failed to score. There was no particular pattern to the wrong answers.

Question (b) discriminated very well, with 15% obtaining three marks and 21% scoring zero. There were good, concise answers that scored three marks for including complementary base pairing and the role of DNA polymerase in joining nucleotides together to form the new DNA strand; often in two or three lines.

Many students failed to read the question carefully and did not answer the question as set. They wrote at length about DNA replication, starting with DNA helicase. These answers were awarded a maximum of two marks, because the question specifically asked how the complementary strand of HIV DNA is made. Many students appeared to believe that DNA actively pulls free nucleotides into place and makes them base pair; some even wrote about condensation reactions. There were students who confused transcription with replication and gave accounts of mRNA production.

Some students appeared to focus on ‘HIV’ and ‘replication’ and gave an extended account of how HIV infects cells, uses reverse transcriptase to make DNA, incorporates its DNA

into host DNA, takes over the cell, is replicated by the host cell, infects new cells and leads to AIDS. They often went onto an additional page, or wrote their answer under (c) on the next page, in breach of instructions given on the front of the exam paper. Many of these students may have found themselves short of time for later questions.

In (c), it was pleasing to find that many students did obey the command word to 'contrast' and gave full statements about the differences between DNA and RNA. Many students knew enough about the structures of DNA and mRNA to give correct contrasting features and 47% obtained all three marks.

Q16.

Question (a) was a very good discriminator. 19% obtained all four marks, 14% failed to score and equal percentages obtained one, two or three marks. Many students had the idea that a vaccine contains antigen and knowledge of antigen-presenting cells was common. There were also many correct statements about plasma/B cells releasing antibodies. Fewer students had the idea of a B cell dividing to form plasma cells. Not many students were able to express clearly the idea of a specific helper T cell or B cell detecting, or responding to, a specific antigen. Quite a few students got confused between the roles of T cells and B cells. Some students wrote at length about memory cells and secondary responses, neither of which was required to answer the question. As in some other questions, this inclusion of irrelevant material often generated additional pages and wasted time that could have been spent on other questions.

Most students obtained one mark in (b) for suggesting greater antibody production with two vaccinations. Almost none went on to make any other suggestion.

In the mathematical requirements section of the specification (pages 62-66), selection and use of a statistical test is not emboldened and so is required content for both AS level and full A-level. This is different from the legacy specification and answers to (c) indicated that most students had not learnt this. Only 6% of students could name the t-test and give the reason as testing the difference between means. Further guidance about teaching statistics is provided in the support materials on the AQA website.

The examiners were expecting statements from the specification in answers to (d). In 'Investigating diversity' (section 3.4.7), genetic diversity is compared (amongst other ways) by looking at base sequences of DNA and base sequences of mRNA. Very few students (3%) came up with both of these but some (27%) managed to express one of them.

Q17.

(a) Most students were able to apply their knowledge to the information in the passage with 92% gaining 1 mark, usually for stating that the virus would be unable to enter the cell. There were students who wasted time in restating the question rather than continuing to explain why disease would not develop. However, over half the students did go on to explain their answer in terms of the virus not being replicated or not damaging cells.

(b) Again, in this question many students simply restated the question and the consequences of an increase in the number of plasma cells and release of antibody rather than explaining the increase. Most were confident that plasma cells release antibodies but it was not uncommon to read about antibodies, rather than B cells, dividing by mitosis. Only the most able students gave the full story to gain 3 marks.

(c) Students often struggled to apply their knowledge in this question. Frequently, it was unclear whether they were writing about the recovered person or the patient infected with Ebola and many incorrectly wrote about the secondary immune response.

There were, however, some excellent responses, showing both a good understanding of the immune response and an ability to use scientific terminology correctly. Many students lost the opportunity to gain marks by writing about “fighting off the disease”, “fighting the infection”, rather than referring to antibodies binding to the viral antigen and destroying the virus.

(d) The idea of antigenic variability was well known but only about half the students were able to explain why this makes it difficult to develop an effective vaccine. Many stated incorrectly that the vaccine would contain antibodies. Other common errors were that the antigen or antibody has an active site and that the antibody would be unable to bind to the virus rather than to the viral antigen.

Q18.

(a) There were some good answers but there were also a lot of confused answers. Many started incorrectly, with statements about the injected antigen attacking myelin. These statements were common amongst the 38% who failed to obtain any marks. Only 10% wrote about the antigen causing an immune response, leading to the production of antibody that then attacks myelin. Some good answers scored all three marks in two lines. There was considerable confusion about what T cells and B cells do.

(b) This part was a very good discriminator. Most students noted that the unusual mitochondria had fewer cristae, or a lower surface area (of cristae) for one mark (23%). Many then went on to associate this with too little ATP production (to keep the neuron alive) for a second mark (45%). Fewer went on to link loss of cristae to less electron transfer/oxidative phosphorylation (26%).

(c) (i) The vast majority correctly stated that an electron microscope would be required but only 43% then gave high resolution as the correct reason. There were many vague references to magnification and scale and a few suggested an optical microscope.

(ii) It was pleasing to see that many gave the correct formula to find percentage and suggested counting normal and unusual mitochondria. This resulted in 34% getting two marks. Only 8% also included a statement that photographs would have to be taken at random, or from a large number of different areas. Those who scored one mark usually just wrote about counting each type of mitochondrion; others forgot to multiply by 100. Incorrect approaches included finding percentage cover, centrifugation to isolate each type and measurements of respiration.

Q19.

(a) Almost 80% of students scored both marks, in a question which tested straightforward recall. Some described pathogens entering cells and reproducing without going on to clarify the damage that would have been caused to the cells. A minority misinterpreted the question and described two ways in which pathogens were transmitted.

(b) The context of this question proved difficult for many students with fewer than half the students explaining that water would move out of the bacterial cell by osmosis because of the water potential gradient. A large number incorrectly wrote about water being drawn out of the blood and washing away the bacteria and many argued that water would enter the bacteria causing osmotic lysis. Few students went on to explain why the loss of water would kill the bacteria

Q20.

(a) Most students successfully used the graph to link the decrease in the percentage of infants vaccinated to fewer cases of whooping cough, with many correctly noting figures from the graph. Fewer students gave a second reason: the most common answer was the fear of side effects with many students linking the vaccine to potential side effects.

(b) 93% of the students scored one mark usually for correctly interpreting the graph and stating that the vaccination rate was increasing. Many then went on to discuss herd immunity in general terms rather than being specific and writing about more people being immune or fewer being susceptible as a result of the vaccination. Examiners expected students to use the correct terminology and students who wrote about 'resistance' to whooping cough did not gain credit.

(c) Two-thirds of the students scored one mark here, for realising that herd immunity was involved, but very few explained clearly how it worked. Examiners were looking for the ideas that there were fewer people in the population in which the pathogen could survive, because many were immune, having been vaccinated, and secondly that contact between infected people and unvaccinated people was therefore less likely. Students confused the terminology with some assuming that all unvaccinated people were infected. Many incorrectly expressed the idea that infants did not need to be vaccinated because they had inherited immunity from their parents and a significant number simply restated the information in the question stem.

Q21.

(a) Over 40% gave the correct response of regulator protein. Students who failed to score often gave a generic response about what should be in a vaccine, 'antigen' being insufficient for this mark. Students should ensure that they relate their answer to the information given in the question.

(b) Students were expected to have seen from the passage that the LDL would bind to a receptor on the surface membrane of the liver cell and then use their knowledge of the structure of the membrane to suggest a suitable route into the cell, for example through a carrier protein or channel protein. Many students failed to use the information in the passage and therefore could only gain one mark. A significant number of students recognised that the LDL would be lipid soluble and could pass through the phospholipid bilayer. This alternative was also credited.

(c) This question discriminated well with weaker students struggling to interpret the information given in the passage. They frequently confused the antibody-antigen response with enzymes, referring to active sites on the antibody or antigen and the formation of enzyme-substrate complexes. There was also mention of receptor "cells" and "antigens on the cell surface membrane of the regulator protein" by students who clearly had a poor understanding of the molecules. However, the more able students were able to gain two marks, usually for referring to the antibody binding to the regulator protein which prevented it from binding to the receptor.

(d) It was clear that many students had learnt a generic answer to this type of question. Most students knew that the control group would be treated the same as the experimental group but the generic response of 'give a placebo' was insufficient because the answer needs to be related to the information in the question. The mark scheme required students to write about injection of saline without the monoclonal antibody. The second marking point, 'treated the same' was sometimes expressed as 'given the same diet', or the 'same amount of exercise' or 'have the same amount of LDLs'. It is worth noting that the same treatment will include the medical experience and measurements taken, so identifying a particular control variable,

such as diet, in isolation, was insufficient to gain this mark.

Q22.

(a) (i) The examiners wanted a statement that a mutation could make the gene inactive and that this would lead to uncontrolled, or very rapid, cell division. About half of students obtained both marks. Some students did not mention cell division but just stated that a tumour would grow; apparently taking 'growth' to mean cell division. The examiners did not accept these terms as equivalent. Some students got into long explanations of how a mutation could lead to a faulty protein and eventually got the first mark point for an inactive gene. Some of these failed to score because they wrote about mutations leading to the production of faulty amino acids.

(ii) A large majority of students managed to convey the idea of the genetic code being degenerate.

(b) Very few students obtained all three marks in this part. This was because they didn't address the reference to 'this antibody' in the stem. The examiners were looking for an observation that 'this antibody' will have a specific tertiary structure, or binding site, or variable region. Some of those who did consider this aspect, failed to score because they referred to a specific 'active site'. Many students obtained two marks for suggesting that the antibody binds either to the receptor (protein), or growth factor, and this prevents growth factor binding to its receptor.

Q23.

(a) It was pleasing to see many good answers to this part that focused on how bacteria are destroyed by phagocytes. Some students drifted into general accounts of the immune response and others began by writing at length about how phagocytes find bacteria. About 30% obtained all three marks. It was common for students to be vague or wrong about the role of lysosomes. It was not uncommon to see references to lysosomes fusing with bacteria, rather than with the vacuole containing the bacteria. The examiners were looking for references to hydrolytic or digestive enzymes destroying the bacteria, rather than just enzymes breaking down bacteria.

(b) 80% obtained both marks. Those who failed to score usually included features of eukaryotic cells in their answers.

Q24.

A number of misconceptions about the immune system, immune response and vaccination were commonly expressed by students in different parts of this question. The same, or similar, misconceptions have been seen in previous papers and have been commented upon in the reports.

(a) (i) Many students did not focus on a comparison of a vaccine consisting of whole cells that had been heat treated with one containing only parts of the bacterial cell. The former might not have been killed, or might contain toxins, whereas the latter could not be alive and would not contain toxin. Many students felt that the introduction of whole cells with their many antigens might overwhelm the immune system. These students did not seem to appreciate that our immune systems are exposed to multiple antigens on a daily basis and are not overwhelmed.

(ii) The examiners were looking for the idea that a whole-cell vaccine would contain many different antigens and each would lead to the production of an

antibody specific to it. Only about a fifth of students obtained both marks here. Most students simply wrote that there would be more antigens and thus more antibodies. This made it impossible for examiners to know whether or not they understood the ideas of different antigens and different, specific antibodies.

(b) This part produced roughly equal percentages of students obtaining 3, 2, 1 or 0 marks. Many started with the assumption that people with whooping cough would have no antibody against the toxin; because if they had the antibody, they wouldn't get ill. Indeed, many stated that only people who had been vaccinated against whooping cough could have antibody against the toxin. In essence, they did not seem to understand that an immune response occurs naturally when someone becomes infected with a pathogen.

(c) Many appeared to find it difficult to accept that a doctor's diagnosis might be wrong and wrote about vaccines not working and the bacterium mutating. About a quarter of students did spot that the scientists' work suggests there might not be a real rise in whooping cough cases and that this might be linked to mis-diagnosis. Another quarter identified one of these points.

Q25.

Parts (a)(ii), (b)(i), (b)(ii) and (c) proved to be good discriminators.

(a) (i) Nearly all students scored one mark and this was usually for suggesting that this method prevented the scientists from being biased. Unfortunately, the second suggestion provided by some also related to the scientists, rather than the volunteers; for example, 'they may have a vested interest'. Students who scored a second mark often referred to reducing the placebo effect or psychological effects.

(ii) One-third of students scored full marks. The most common mark points awarded were for suggesting that different types of cigarette contain different amounts of nicotine, different amounts may be absorbed, different amounts may be excreted and that the volunteers may have different blood volumes. Unfortunately, a lack of precision let down some students; for example, 'they smoked different cigarettes' and 'they had different body masses'.

(b) (i) Just over half of students scored at least two marks. This was usually for mentioning that nicotine will not bind to the protein, so the smoker will not feel rewarded. Surprisingly, few students clearly expressed the idea that the vaccine stimulates the production of antibodies to nicotine, or that these antibodies bind to nicotine. A common misconception seen in weaker responses was that the vaccine *contains* antibodies to nicotine. Similarly, some students thought that *this* vaccine contained a weakened strain of bacteria. Generally, there were three incorrect approaches to this question, which were all due to not reading the introduction carefully enough. The first was that the vaccine *causes* the release of reward chemicals, meaning that a person would not need to smoke. The second was that the vaccine stops smokers from feeling addicted, rather than stopping them from feeling rewarded. The third was that the antibodies to nicotine bind to the protein in the brain, instead of to nicotine. Unfortunately, some students had the second mark disqualified for referring to the protein receptor in the brain as an enzyme. A minority also thought that the ability of the vaccine to stop people smoking could be spread within the population to other smokers by herd immunity.

(ii) Just under half of students scored at least two marks. The most common mark

points awarded were for appreciating that people choose to smoke, the vaccine would be expensive and less money would be needed to treat the effects of smoking. Relatively few referred to it being unethical not to treat smokers, or that money would be better spent in preventing people from smoking. Students who failed to score often gave vague responses; for example, 'if it is free, more people will stop smoking' and 'it will prevent people from dying of cancer'. A minority suggested that the vaccine should not be used at all, due to the Government losing millions of pounds each year in tax on cigarettes. Some of the weakest responses did not answer the question set. These typically contained stock How Science Works phrases such as, 'it is only one study' and 'we do not know the sample size'.

(c) It was disappointing that only one-fifth of students scored at least three marks. Again, weaker responses often contained stock How Science Works phrases, which did not apply specifically to this investigation. The question clearly asked students to *use the data* to evaluate the statement made by the journalist. This said, many students did note that high antibody responders are more likely to stop smoking. Many also realised that the placebo group and low antibody responders had a similar percentage of volunteers who stopped smoking. The next most accessible mark point was that the volunteers may start smoking again after five or six months. Better responses also noted the peak, or drop, in the concentration of antibodies. However, some failed to mention when this occurred, or quoted an incorrect time from the graph. Relatively few students suggested that only a small proportion of the population may be high antibody responders, or that the large sample size produced more reliable or representative results. Overall, it was evident that many students did not analyse the data in the graph and table in enough detail, particularly in relation to the timing of events.

Q26.

(a) (i) This was done well by many students. Where the mark was not given it was usually because a student stated that the antigen was foreign but did not go on to add that it would cause an immune response.

(ii) Difficulties with this question were linked to poor understanding of the ways in which substances pass through membranes. Weaker answers referred to the antigens not being 'allowed' through, rather than incompatibility between the shape of the antigen and the shape of trans-membrane protein channels.

(b) Many students scored full marks. Rather than microfold cells being the route by which vaccines could enter the body, weaker responses included ideas such as the vaccine being given as treatment for a disease, or people being injected with microfold cells.

Q27.

The questions in each part of this question related to the short comprehension passage. Very many students appeared to pay little attention to the contents of the passage and many did not read the questions carefully enough

(a) This produced some very good answers where students clearly described invasion by pathogens, their reproduction, invasion of host cells and production of toxins. They then linked these to death of host cells and tissues. About a third obtained three marks. Some students concerned themselves with the immune response that they had been told the people with AIDS did not have; they scored very poorly.

(b) A commonly stated misconception in this question was that vaccines are given after

infection, to treat rather than to prevent.

(i) Nearly forty percent scored one mark, either for the idea of there not being time for antibodies to destroy HIV, or for there not being time for memory cells of the immune system to respond. Few gave complete explanations; for example, following up the antibody point by stating that antibodies do not / cannot enter cells to follow HIV.

(ii) Students did better in this question and both lines of argument were seen. The commonest correct answers involved different antigens being produced and antibody not being able to bind any more. Students' powers of expression frequently let them down here.

(c) This question was notable for the use of rote answers; "there might be side effects", "it might cost too much", "it has only been tested on animals", "it's not ethical.....". The question asks about these types of vaccines, the ones discussed in the passage, with their various characteristics. A few very good answers were seen, where students did discuss, for example, the possible perils of an attenuated virus as a vaccine, when HIV is stated to show a lot of variability. In a 'real world' context, it was interesting to note that almost no students appreciated that one would become HIV positive if one had been vaccinated. Encouragingly, one of the more common acceptable observations was that vaccination might encourage unsafe practices, which could spread HIV if the vaccine did not work.

Q28.

(a) It was clear that many students had learned to define key terms and these students gave clear and accurate answers. Others were less specific, most commonly stating that a pathogen was "something" that caused disease. This was insufficient to gain the mark.

(b) Many students gained all four marks. The main reason for failing to gain marks was for not specifying the idea of fusion of the lysosome with the phagocytic vesicle. Some students, however, failed to read the question properly and wrote in more general terms about B cells and T cells or lymphocytes, ignoring phagocytes.

(c) Poor terminology let down students who clearly understood the concepts. Too many used active site terminology and were unable to gain the first marking point. The second marking point tended to be gained more often with the majority of students correctly referring to antibody and antigen being complementary, fitting and binding. Those who did not get this mark failed to do so by writing about the antibodies binding to the pathogens rather than to the antigens.

Q29.

(a) Many students gave the correct answer, hydrolysis. Those who failed to score usually confused hydrolysis with condensation.

(b) Many students correctly identified that the peptide was too large or insoluble and therefore gained one mark. Only the more able students went on to explain that peptides would therefore not be able to pass through the carrier or channel protein. There was a significant number of students who wrote about active transport despite facilitated diffusion being referred to in the question.

(c) This question was generally answered well with most students recognising that the peptide would be considered "foreign" or "non-self". Those students who failed to score often referred to the peptides as cells.

(d) Some students failed to use the information in the passage, which stated that the drug had already been tested on patients with coeliac disease, and produced answers referring to trialling on animals or people without the disease. The majority correctly wrote about side effects, though some gave this answer twice with slightly different wording. Large numbers of answers gave generic responses here such as age or gender, without giving any thought to the context of the question.

Q30.

(a) Most students correctly identified the evidence as relating to four polypeptide chains. Incorrect answers usually centred on the presence of variable regions or of hydrogen bonds. There was some evidence of the difficulties that students find in interpreting diagrams with numerous references to two polypeptide chains.

(b) Most students clearly appreciated that an antigen is able to bind to an antibody to form an antigen-antibody complex. Not all, however, were able to identify the binding site of the antibody as having a complementary shape to the antigen. Many of the less able students confused antibodies with enzymes. Use of the term active site rather than binding site was perhaps understandable, but many went considerably beyond this in writing of substrates and enzyme-substrate complexes. There were also many students who failed to maintain the necessary focus and wrote at length of plasma cells, memory cells and vaccines.

Q31.

The starting point for questions requiring longer responses must be careful determination of precisely what is required. This question required students to explain how vaccines protect people against disease but few could resist the temptation to describe in great detail everything they knew about immunology. This often resulted in the allocated space being filled with material that, at the very best, could only be regarded as of marginal relevance. Most students should have been able to access the first three points on the scheme and indicate that antigens on weakened or dead pathogens stimulated the production of memory cells. The fact that credit was not always awarded stemmed from interchangeability of the terms pathogen and disease, and uncertainty over the origin and nature of memory cells. The second part of the mark scheme referred to the generation of a secondary immune response. Those students who finally arrived at this concept, often did no more than offer a few passing thoughts at the very end of the page or on an extra sheet. As always with questions on this topic, the use of language was often far from convincing and there were many references to antibodies "fighting" and memory cells "remembering".

Q32.

(a) Nitrogen-fixing was the commonest wrong answer in this question. The majority of responses were correct.

(b) This question was answered poorly because students did not think through the processes that were taking place in the reed bed. There were many incorrect responses referring to processes in the reeds that result in the formation of nitrates from ammonia / nitrite. Some then went on to gain one mark for active transport of these nitrates into the plant roots. Better students correctly linked the use of ATP from aerobic respiration in the active transport of nitrates, and wrote clearly and concisely. There was a surprising amount of confusion between diffusion and active transport, with active transport being said to be needed to diffuse nitrogen-containing substances from areas of high to low concentration. The oxygen was also thought to create a concentration gradient to allow the roots to take up the nitrogen-containing substances by diffusion.

(c) There were some very clear answers to part (i) from students who understood that too fast a flow would not allow time for the nitrification to occur, hence the decrease in concentration of nitrates. There was also not enough time for the saprophytes to decompose the sewage to release ammonium compounds. Some failed to mention the ammonia being converted. Other answers suggested that the soil would become waterlogged, preventing the action of the nitrifying bacteria, or that the reeds would take up more of the nitrates or that numbers of denitrifying bacteria would increase, converting the nitrate to nitrogen gas. A number thought that if the flow was too fast, the reeds would be unable to take up the nitrates, so they would end up in the lake. The fast flow was also thought to reduce the oxygen concentration in the water, thus preventing the action of the nitrifying bacteria. There was also confusion with leaching and eutrophication. There were only very occasional references to the bacteria being washed away by the fast flow. The fast flow was also said to maintain a steep diffusion gradient and increase uptake by the plant roots.

In part (ii), it was clear that many students had learnt this topic thoroughly and included all marking points. Weaker students could not explain the increase in decomposers breaking down the dead plants and using up the oxygen in the water in their respiration. The algae were often described as 'feeding' on the nitrates. A common incorrect reason for the death of the fish was a lack of food once the plants in the lake died. A minority of students had no understanding of the process of eutrophication and thought that dehydration and osmosis caused the fish to die or that high nitrate concentrations were toxic to both fish and algae. Increasing concentrations of carbon dioxide were also thought to be responsible for the death of the fish.

Q33.

(a) (i) Many candidates gave a generic answer, failing to refer to the passage as instructed. These candidates often scored only one mark for explaining that an antigen causes an immune response. Candidates who scored both marks used the information given to explain that, in this example, the antigen was a protein on Chlamydia.

(ii) In this question, candidates were more confident in using the information from the passage and most gained at least a mark for explaining that the proteins on the Chlamydia cell and the heart were similar. There were candidates who confused antigens with antibodies and even enzymes but many candidates gained a second mark, usually by explaining that antibodies would attack the heart muscle cells. There were a number of excellent answers that showed a clear understanding of the immune response.

(b) A number of candidates did not go further than the information given in the question, simply stating that the vaccination would prevent Chlamydia infection. This was not credited. Candidates who considered the information in the passage wrote about the possibility of preventing atheroma or, if the human proteins were similar to those in the mouse, the risk of causing heart disease. There were also creditworthy references to the cost of a vaccination campaign being higher than alternative methods of reducing the incidence of Chlamydia. Unfortunately, many limited their answer to just one factor rather than evaluating the suggestion as instructed.

Q34.

(a) Phagocytosis was well understood by candidates and many gained full marks. Many, however, wasted time by describing antigen presentation which was not required. Almost all candidates knew that the bacteria would be engulfed and many referred to their inclusion in a phagosome or vacuole. Weaker candidates failed to

gain marks through imprecision, e.g., not realising that the lysosomes fuse with the phagocytic vesicle and just writing about them releasing enzymes or not specifying what sort of enzymes and then repeating the stem by saying the bacteria were destroyed without any mention of digestion or hydrolysis.

(b) Many candidates failed to realise that this question was about cell adaptation. There was a lot of confusion between adaptations of the cell and of the intestine wall generally, with many answers focusing on factors such as a good blood supply and maintaining a steep concentration gradient. Such responses were not relevant to this question. Many candidates had a good understanding of glucose co-transport and described this in detail, usually gaining two or three marks, even though their answers were not focused on cell adaptation. Most scored one mark for understanding a large surface area was involved but many attributed this to villi rather than to microvilli. Better candidates gained a further two marks for explaining the cells would have a large number of mitochondria that provide the ATP for active uptake.

Q35.

(a) (i) This caused little difficulty for most candidates with the vast majority gaining at least one mark for suggesting that *C. difficile* is resistant to antibiotics. Although many candidates realised that the other bacterial species would be killed, they failed to gain a second mark by not stating that there would be an increase in the number of *C. difficile*.

(ii) Most candidates gained this mark by suggesting that the immune system would be less effective. There were several answers linked to older people taking lots of antibiotics. These responses were not credited.

(b) Although the majority of candidates obtained at least one of the two marks available, there was still some confusion, particularly with weaker candidates, about the precise role of methicillin. Most candidates realised it was a competitive inhibitor but a significant number referred to it possessing an active site. Approximately forty percent of candidates provided a clear accurate explanation of competitive inhibition by methicillin.

(c) (i) The majority of candidates had little difficulty explaining that some of these patients were already ill and this illness could be the cause of death.

(ii) The vast majority of candidates gained this mark by describing the increase in the number of deaths up to 2006 followed by a decrease.

(iii) Less than a third of candidates could correctly calculate the percentage increase in the number of deaths caused by MRSA in Wales from 1996 to 2006. A small percentage of candidates obtained a single mark for reading figures from the graph but almost sixty percent scored zero.

Q36.

(a) Relatively few candidates appeared to be aware that points on a graph should be joined with straight lines if it is felt that the position of intermediate points cannot be predicted reliably. Given that this decision had been made by candidates in drawing their graphs in stage 2, this was somewhat surprising.

(b) Although many candidates were able to describe how the curve rose to a maximum value at 180 units or a dose of 0.25 g per kg, a significant number missed the point plotted for a zero dose. Other candidates misread the second point as representing

a dose of 0.5 g per kg.

(c) It remains disappointing that so few candidates can calculate percentage increase or decrease. There were many incorrect answers to this question, frequently from otherwise sound candidates.

(d) Most candidates appeared to appreciate that calculating the dose per unit mass allowed differences in mass to be considered and a comparison to be made. Many responses, however, failed to gain credit because of the vague use of terms such as “bigger mice” and “size” rather than mass.

(e) It would appear that some candidates had been taught about the immune response in much greater detail than required by the specification. This additional detail tended to confuse rather than help the candidates and reduced their marks for this question. It was relatively uncommon to see three marks awarded for what should have been a straightforward account. Common errors made by less able candidates involved the confusion of antibody and antigen or failing to identify the antigens as being on the surface of the sheep red blood cells.

(f) Most candidates correctly pointed out that this investigation was carried out on mice and, therefore, the results might not apply to humans but only the better candidates were able to suggest a second valid reason.

Q37.

(a) Candidates’ knowledge of classification allowed many to make valid statements in their answers to part (a) about cats and cheetahs being from the same family or both being feline. Occasional candidates incorrectly referred to cats and cheetahs belonging to the same species. In part (b), some candidates were able to interpret the grafting of skin from one part of an animal to another as a test to see whether rejection would occur in these circumstances. The word ‘reaction’ was not considered to be synonymous with the specific biological meaning of rejection.

(b) Candidates could have taken one of two approaches in answering part (a). They could either have concentrated on the speed of rejection or on the closeness of the genetic relationship between relevant animals. Despite this, this part of the question was not answered well and responses tended to lack the necessary precision to gain credit. Most candidates responded to the word reliable in part (b) with a suitable comment about the size of sample, but there were a few responses that were correctly worded in terms of the duration of the observation. Although many of the answers to part (c) were correctly based on the inference that cheetahs must share similar antigens as skin grafts were tolerated between animals, responses to part (d) were often poor. There were many confused accounts that failed to reflect the fundamental idea that proteins such as antigens are coded for by DNA and so any variation in the amino acid sequence of the protein implied a variation in the DNA coding. Candidates rarely answered in these simple terms.

Q38.

(a) Two thirds of candidates were aware that the vaccine needed to be given before girls are sexually active or likely to carry HPV. However, this was often poorly expressed by weaker candidates e.g. ‘this is when girls reach puberty or are sexually mature’. Other typical responses attempted to explain why the vaccine was given in general terms, rather than to this specific age group e.g. ‘to prevent girls developing cancer later in life’.

(b) One third of the candidates had the idea that different types of HPV have different

antigens. However, only better candidates wrote about the consequence of this in terms of memory cells and antibodies. Weaker candidates were let down by poor expression. Responses such as ‘the immune system does not recognise the virus’, ‘memory cells do not remember the virus’ and ‘antibodies cannot fight the virus’ were seen. A minority of candidates thought that the vaccine contained antibodies.

(c) Nearly half of the candidates had the idea that more memory cells or more antibodies would be produced. However, only the very best candidates mentioned both for full credit. Two misconceptions were seen in the responses of weaker candidates. The first was that each injection of the vaccine was based on a different strain of HPV and would therefore provide ‘better immunity’. The second involved safety. They thought that ‘if given all at once, the immune response would be too strong’. Similarly, many unqualified references to the primary and secondary responses were seen.

(d) Two thirds of the candidates gained at least one mark for stating that cancer takes many years to develop or that it takes time for young girls to become sexually active. Candidates who failed to score often wrote that ‘it takes time to develop immunity’ or ‘it takes many years to obtain data’. Some weaker candidates wrote about immunity being passed on to offspring or that it would take many years to vaccinate 80% of 12- 13 year olds.

(e) 75% of candidates gained full credit for stating that cancer can be caused by other factors or that the vaccine may not work. Weaker candidates often repeated information in the passage and wrote that smear tests are needed to remove abnormal cells before cancer develops. A minority thought that cancer is infectious and that smear tests detect the virus.

(f) Only better candidates were aware that people who are vaccinated will destroy the virus or not act as carriers. Very few of these candidates appreciated that people who are not vaccinated are therefore more likely to meet people who are vaccinated. Many candidates simply repeated the stem of the question and stated that ‘if vaccinated, people cannot spread HPV to others’. Weaker candidates often referred to the ‘disease’ being destroyed rather than the virus.

Q39.

(a) Only the most able candidates gained full credit on this question. However, most candidates gained one mark for the idea that cervical cancer could be caused by other factors. Unfortunately, some candidates misinterpreted the graph and considered it to show the percentage of women with cervical cancer, rather than the percentage of women with a specific type of HPV. It was very clear that these candidates did not realise that all women in the investigation had cervical cancer. Consequently, this led to responses that were out of context such as that ‘66% of women with HPV16 have cervical cancer’. Better candidates were able to criticise the data. They usually referred to the absence of a control group or suggested that cervical cancer may increase susceptibility to HPV. Weaker candidates often gave vague answers that were not qualified e.g. ‘it does not prove that HPV causes cervical cancer’. Similarly, they did not usually refer to specific types of HPV.

(b) (i) Approximately 40% of candidates gained one mark. This was almost always for stating that an antigen stimulates an immune response. Relatively few candidates made reference to the chemical nature of antigens.

(ii) Just over a third of candidates scored full marks but 60% scored at least two marks. A number of candidates were aware that vaccination causes the production of memory cells or that memory cells remain. However, many

candidates had the idea that memory cells ensure a rapid response to the same virus if encountered again. Unfortunately, these points were often poorly expressed by weaker candidates such as in stating that ‘memory cells remember the antigen’ or that ‘they fight the germ quicker’.

(c) Most candidates suggested that vaccinating young men would reduce the spread of HPV to females. However, it was usually only better candidates who explained this in terms of vaccinated males destroying the virus or not acting as carriers. Weaker candidates usually expressed this idea poorly e.g. ‘vaccinated males cannot be infected’. A number of creditworthy references to herd immunity were made, although it should be noted that this term is not a requirement of this unit. Some candidates suggested that HPV may cause other cancers in males and this was also credited. The most common misconception involved vaccinated males passing on immunity to their children.

Q40.

(a) Over 90% of candidates gained this mark, usually for ‘virus’. Relatively few referred to ‘fungi’. The few candidates who failed to score usually repeated ‘bacteria’ from the stem of the question or gave a specific example of a bacterium or virus.

(b) Many candidates gained full marks for this question, although a minority misread the stem of the question and gave ways in which a pathogen could gain entry into the body. The most common mark awarded was for the production of toxins. Unfortunately, some candidates failed to gain the second mark through a lack of detail e.g. ‘damages the body’ and ‘infects cells’.

(c) (i) This question was poorly answered by most candidates. Only the most able were aware that monoclonal antibodies were produced by the same B cell or B cell clone. There was evidence of widespread poor expression and responses usually fell into one of two discrete camps. Candidates who focused on the ‘mono’ aspect of ‘monoclonal’ frequently referred to these antibodies ‘only binding to one antigen’ or ‘being produced from a single antibody’. Candidates who focused on the ‘clonal’ aspect usually gave responses that were out of context, such as ‘these antibodies are cloned’ and ‘they are genetically identical antibodies’. Disappointingly, very few candidates mentioned B cells.

(ii) This question proved to be a good discriminator. The most common mark awarded was for ‘tertiary structure’. Weaker candidates usually went straight into an explanation of why monoclonal antibodies are specific in terms of binding, shape or fit. However, a number of these answers lacked detail regarding what these antibodies bind to. Relatively few of these candidates used the term ‘antigen’. In such cases, the terms ‘bacteria’ or ‘pathogen’ were typically used. A number of candidates also confused antibodies with enzymes, with references to ‘active sites’ and ‘antibodies being complementary to the substrate’. There were, however, some highly impressive answers given by the more able candidates. These usually gained full marks and often gave more detail than that shown on the mark scheme.

(d) Most candidates gained at least one mark for the idea of reducing the spread of disease. The more able qualified this by explaining that rapid identification allowed infected cattle to be isolated and treated. Relatively few wrote about infected dairy products not being sold. Weaker candidates often gave vague arguments that related to animal rights and economics. These usually involved less distress being caused to the animals, not having to transport the animals or money being saved due to the samples not having to be sent to a laboratory. Such responses were not

credited. Similarly, a minority of candidates incorrectly thought that the monoclonal antibodies were being used to treat infected cattle, rather than as a diagnostic tool.

Q41.

(a) Most candidates had little difficulty obtaining at least one mark by referring to the production of toxins by pathogens. However, a significant number of candidates did not specifically refer to cells or tissues being damaged but instead described how pathogene enter the body or wrote about damage in general terms.

(b) It was disappointing to find a significant number of candidates describing a vaccine as 'a weakened form of a disease'. However, most candidates did refer to the production of antibodies or memory cells following vaccination. Some candidates did suggest that a vaccine contains antibodies and provides passive rather than active immunity.

(c) (i) This question caused little difficulty with the vast majority of candidates able to provide at least one valid factor, often age or gender. Other common correct responses related to obtaining healthy volunteers and individuals who had not been infected with TB or had been previously vaccinated.

(ii) This proved very difficult. Only a small percentage of candidates obtained this mark by suggesting that the two vaccines have similar antigens. Most candidates simply stated that the two vaccines were most effective when used together.

Q42.

(a) Over two thirds of the candidates correctly named the nucleus as the structure which confirms that *G. lamblia* is a eukaryotic organism. Ribosome and flagellum were frequent incorrect responses.

(b) Most candidates gained this mark for stating that the sucker enabled *G. lamblia* to remain in the intestines rather than being moved out as substances passed through. However, some candidates suggested the sucker enabled nutrients to be absorbed or somehow prevented digestion of the organism.

(c) (i) Approximately one in five candidates obtained both marks for this calculation. A similar number of candidates did gain one mark for showing some valid working in attempting the calculation.

(ii) The vast majority of candidates did not obtain this mark as they suggested that the number of cases would increase in the summer due to an increase in water consumption. Very few candidates suggested that an increase in temperature could lead to an increase in the number of *G. lamblia* in contaminated water.

(d) (i) Most candidates stated that monoclonal antibodies are the identical with no reference to their shape or the idea that they are specific to a particular antigen.

(ii) Many candidates obtained this mark often by referring to the complementary shapes of the antibody and *Giardia* antigen. Fewer candidates mentioned the tertiary structure or the variable region of antibodies. Most incorrect responses suggested the antibody has an 'active site' or the 'same' shape as the *Giardia* antigen.

(iii) As expected this proved to be a difficult question. Most candidates had difficulty understanding the flow chart and gave a variety of incorrect responses. Despite the information provided in the stem of the question many candidates suggested that the *Giardia* antigen would remain on the plate and cause a positive result.
Other misconceptions related to the enzyme reacting with the antigen or with the antibodies. Approximately forty percent of candidates obtained one mark for realising that the second antibody with the attached enzyme would remain on the plate. Far fewer of these candidates went on to explain that the enzyme would react with the substrate to provide a yellow colour.

Q43.

(a) Although it was evident that most candidates had a good idea of the role of phagocytes, poor use of terminology often resulted in marks not being awarded. It was common to see responses such as phagocytes 'fighting disease' or destroying 'foreign bodies' or 'infections'. Nevertheless, approximately a third of candidates obtained both marking points.

(b) (i) Most candidates obtained one mark for stating that the lungs would not fully inflate or deflate. However, very few candidates obtained a second mark for suggesting that breathing out would particularly be affected or that the rate of diffusion would be reduced. There was some confusion over the meaning of the term *elasticity* with many references to 'lungs contracting and relaxing'.

(ii) This proved to be an effective discriminator. The vast majority of candidates obtained at least one mark often by referring to the presence of scarred or fibrous tissue in the lungs. Most candidates then gained a second mark by linking this to a reduction in the surface area for effective gaseous exchange. Fewer candidates specifically referred to the thickening of the alveolar walls but instead mentioned thickening of lung tissue. However, a significant number of candidates were able to link this thickening to a longer diffusion pathway.

(c) (i) Most candidates obtained this mark using the information in the passage to explain that lung cancer develops 20 – 30 years after exposure to asbestosis. Candidates failing to gain this mark often provided incomplete responses such ae 'it takes a long time for cancer to develop'.

(ii) The vast majority of candidates obtained this mark by referring to smoking.

Q44.

(a) There were many excellent answers to this part of the question that described phagocytes engulfing microorganisms and the subsequent role of lysosomes. Where difficulties arose, they not infrequently stemmed from too much, rather than too little, knowledge and there were some extremely involved and often confused answers that wrote in great depth about antigen presentation, opsonisation, b cells and t cells, none of which were relevant in the context of this question. The treatment of immunology should be confined to the principles set out in section 3.1.6 of the specification. Candidates will only be required to recall information explicitly described in this section.

(b) From the evidence in the answers to part (i), most candidates appeared to appreciate that a person might be infected with different strains of the influenza virus. Only the better candidates, however, were able to explain this in terms of memory cells. Less convincing answers were seldom expressed in appropriate scientific terminology.

Antigen, antibody and antibiotic were often used interchangeably in these responses, and there were many references to ‘attacking while the immune system was still weak’.
In part (ii), candidates frequently ignored the instruction to ‘Use your knowledge of antigens’ and merely identified Strain 1 as the most frequent. There were however some excellent answers.

Q45.

(a) Most candidates were able to extract the relevant information from the passage and explain that many of those with the illness failed to see a doctor. The concept of a ratio in part (ii) proved difficult for some to understand. Although there were many correct answers there were many that should have been considered, at best, to have been improbable.

(b) Many candidates were able to comment on the identical nature of the sugars in the bacterial antigens and on the surface of nerve cells. For some, this led to a comprehensive account of antibody binding and the formation of an antibody-antigen complex. Others rather lost their way at this stage and did no more than suggest that this led to antibodies ‘attacking’ the nerve cells.

(c) There were many lengthy accounts presented in answer to this part of the question. Able candidates frequently described the entire process of ventilation and extended their answers onto additional sheets before eventually arriving at a point where they describe the effects of paralysis. It was clear, however, that many candidates had little idea of the precise role of the diaphragm. It was not infrequently described, for example, as ‘pushing the ribs up and out’. Such statements as ‘breathing in causes the diaphragm to flatten’ were common and revealed confusion between cause and effect.

Q46.

(a) This part of the question attracted some very detailed descriptions of everything to do with the immune system, including T-lymphocytes, suppressor cells and the role of macrophages. However, in some of these accounts the main points were missed. Many candidates appeared of the opinion that plasma cells made memory cells. Others considered that lymphocytes were antibodies. In a few cases, plasma cells sometimes unfortunately became plasma or even plasmids. The idea that the B cells clone and these differentiate into plasma cells or memory cells seemed to elude quite a few candidates.

(b) Most candidates correctly identified the glycoprotein and gave an acceptable reason.

Q47.

(a) This generally proved a good opening question, but weaker responses were less specific about the nature of the ‘chemical’, or just referred to a ‘substance’ that stimulates an immune response.

(b) It was not uncommon to see all marks achieved. Better candidates appreciated that the B-lymphocytes would divide by mitosis, or produce clones, and then produced an accurate description of the production of antibody-secreting plasma cells and memory cells. Weaker responses discussed the role of T-lymphocytes, pathogens, plasmids or assumed that memory cells already existed.

(c) While many could correctly identify the glycoprotein as the component, the reason

provided was often unconvincing. At a simple level, glycoproteins were on the surface of the virus -not the cell - but few identified that difference in shape, from body proteins, would enable recognition of the antigen. An accurate calculation was rarely seen with few able to achieve both marks and some did not attempt it. Lack of clear working meant that it was not possible to award any credit in many cases.

Q48.

(a) This was well answered, with many candidates getting two marks and most gaining at least one mark. The failure to gain marks was due largely to the poor use of language with weaker candidates using the term disease rather than antigen.

(b) Although well answered by many candidates, part (i) caused some difficulties for candidates who gave the well learned "antibodies are specific" response but did not relate this to the context of the question. The data in the stem of (ii) gave problems to candidates who did not precisely identify the antibody to which they were referring. The better responses clearly differentiated between the first antibody and the antibody-enzyme complex. Clarity of written responses also affected part (iii) where the best responses clearly differentiated between the enzyme active site and the antibody-binding site. The poorer responses tended to confuse these and often failed to gain marks as the examiners were unable to determine exactly to which molecule or stage in the process the response was referring.

Q49.

(a) Generally answered quite well, though, because the stem clearly indicated the yield of antibodies was higher with the secondary response, answers that simply stated ”more antibodies produced’ were not credited. Examiners were looking for the faster rate of production as this was not given in the stem.

(b) Although this question was attempted by most candidates it showed that some thought antibodies can die.

(c) The better candidates tended to respond in terms of eliciting an immune response to the antivenom and gained the mark. Some candidates responded in terms of ethical issues and vegetarianism. Examiners found many of these responses were too vague or below the level needed to gain credit.

Q50.

(a) This proved an excellent discriminator. Some achieved three marks but there was a tendency to include interpretation rather than method or to suggest impractical steps such as adding the test plate to the solution. Flow charts seem to be unfamiliar to many candidates.

(b) Whilst a few scored two here, many failed to gain marks by discussing enzymes and active sites, failing to realise that antigens with a specific shape were involved.

Q51.

(a) Few candidates scored two in the first part and vague references to ‘fighting infections’ were common as was confusion of antigens with antibiotics. In part (ii), some candidates appeared to know the sequence of events but in many cases limited marks were gained because of incorrect biology and discussion of previous infections which ‘the body remembers and is ready to fight off the second time’. B and T cells were confused, the exact role of mitosis was not well known and few

explained the specific antibody synthesis by plasma cells. Some answers used bacteria as the infective agent.

(b) This section scored the majority of the marks for the question in most scripts. Problems arose mainly where candidates failed to apply their knowledge to the situation. As a result, the gene was transferred to a plasmid which was put into maize or left in a test tube. In a few cases, the first part of the question led to suggestions of infecting the maize with various blood cells.

(c) Several good answers referring to passive immunity were seen here but many failed to gain marks through lack of precision in their answer.

(d) Examiners were looking for more than a simple response about cost here. Valid ideas on the ethics of this work or the possibility of transferring a disease were awarded marks.

Q52.

In part (a), there were large numbers of answers which lacked specificity, such as preventing the bacteria escaping. There were the inevitable references to 'fair tests' and suggestions that bacteria entering the dish might somehow negate the effect of the antibiotics. In (b)(i), many poor answers were seen. Few commented on slow diffusion. Many simply stated that an antibiotic with a small clear zone could still be effective. In part (ii), most candidates identified **B** and gave a suitable answer. A few candidates chose **A** because it had the biggest clear zone, and some even gave a named antibiotic such as streptomycin or chloramphenicol.

Q53.

Part (a) was well known by most candidates. However, in (b)(i), very few gained both marks for the correct answer. Many gave a percentage instead of a number. Where the answer was wrong, it was very difficult for examiners to give credit for correct methodology because most candidates showed little organised working. Many candidates misread the graph, for example reading 74 million instead of 7.4. In (ii), most candidates could see that the percentage being vaccinated was rising each year, while the population was growing more slowly. In (iii), there were many vague answers referring to building up immunity, without any detail of how. Some simply stated that it was a good idea for elderly people to be vaccinated because they are the most at-risk age group. In part (c), there were many good answers, though many candidates referred to this being an attenuated vaccine.

Q54.

(a) Definitions of antigens and monoclonal antibodies indicated some confusion and there were many references to bacteria, foreign structures, one substance attacking another, or the body fighting off disease. Precise accounts were infrequent.

(b) Again imprecise answers abounded, showing lack of understanding. In part (ii), candidates were required to explain that the enzyme had to be present and why it would not be. This needed extensive linguistic skills which were not always apparent. Some did make good use of the diagrams.

Q55.

(a) This was poorly answered, despite the fact that similar questions have been set on many previous BYA3 papers. Many candidates simply stated that an antigen was a

marker on a cell, without indicating its molecular nature. Few referred to its role in producing an immune response, simply limiting their answer to cell recognition.

(b) In part (i) many candidates started both lines at the same point on the axes. Some who did this also failed to indicate which was the first injection and which was the second. In part (ii) many candidates thought the second injection was a test to see if the first injection worked. Some thought memory cells were not produced until the second injection. There were also references to antigens changing and malaria having two hosts. In (iii) it was very clear that most candidates did not understand what an antigen is. Most candidates thought that the vaccination was attenuated and made with a weakened strain of malaria which cannot cause disease. There were also frequent references to the antigens having been killed.

(c) Many candidates suggested looking for burst/damaged red blood cells, or looking for the antigens or antibodies in the blood. Only a minority of candidates correctly realised that parasites would be visible under the microscope.

Q56.

(a) Many candidates understood the basic principles of natural selection underlying this part of the question and better answers related these to the development of resistance in malarial parasites. Responses, however, were frequently marred by imprecise use of terms. Thus malarial parasites were variously described as developing resistance, immunity or, in some cases, allergies to the drugs concerned, while resistance was described as taking place in bacteria, the disease or even in the human population.

(b) Evidence from BYA5 suggests that many candidates understand that probabilities are combined by multiplication. However, they were unable to apply this principle to the example in this part of the question. The most frequent response was to add the two figures. The resulting value of 1/250 then proved difficult to explain, and the simple idea that the probability of being infected by a strain of malarial parasite resistant to both drugs was much lower eluded most.

(c) The concept of a control proved surprisingly unfamiliar to most candidates and even the best seldom progressed beyond explaining that a control offered a standard against which to compare the effectiveness of the vaccine. This idea should have given rise, in part (ii), to injection with saline only in an otherwise identically treated control group. Answers ranged from those who clearly failed to appreciate the nature of a control and discussed issues which were largely ethical in nature, to responses which were in varying degrees incomplete. Such responses included making sure that both groups “lived in the same place” or “were the same age”, ignoring the fact that these were only part of a whole range of factors which should have been kept constant. Evidence from this question and from the coursework suggests that the issue of controls is one that needs to be addressed by centres.

(d) Better candidates experienced little apparent difficulty in identifying the correct percentages here. Incorrect answers fell into no set pattern and most responses which could conceivably be given arose at least once.

(e) Many candidates were obviously of the opinion that restriction enzymes function in a way that is totally different from other enzymes, and attempted to explain their specificity in part (i) in terms of base pairing. Others clearly understood the principles involved but neglected to relate their understanding of enzyme action to this particular question. A lack of precision characterised many of the answers to

part (ii). Thus there were frequent references to adenine and thymine but not to these bases forming the restriction sites. However, most candidates were able to equate the frequency of cutting to the small size of the resulting fragments.

Q57.

Many candidates gained at least five marks in this question with weaker candidates scoring at least three.

(a) Most candidates gained one mark. Cost was rarely mentioned. Answers were often vague and lacked precision.

(b) (i) Most identified protein synthesis. Candidates tended to just give the sequence of events rather than what would happen if they stopped. Weaker candidates just repeated the question. Some candidates were confused between transcription and translation and others wrote about DNA replication and mRNA production.

(ii) There were many good answers but some just said ‘different sizes’.

Q58.

Most candidates gained at least four marks in this question.

(a) The majority of answers lacked detail and a clear understanding of the correct sequence of events. Candidates had to select the facts needed to answer the question. Many gained a mark for replication by mitosis/cloning. All the other marking points were seen, with stronger candidates gaining all the marks. Few mentioned the importance of specific B lymphocytes, or differentiation resulting in plasma cells that release antibodies.

Antigen, antibody and receptor were often confused. Many mentioned memory cells and T cells.

Many candidates gained more than half the marks because there were six points on the mark scheme.

(b) A large number of students wasted time describing how to isolate the gene. The gene had already been isolated. Marks were gained for references to restriction endonuclease, plasmid and ligase. Few suggested how to transfer plasmid into bacteria.

Q59.

(a) Answers were generally good but some candidates confused the position of ligands and receptors. Some candidates did not know that humans are mammals.

(b) Most candidates gained the mark for enzymes being deactivated but then failed to describe a specific relevant effect.

(c) Some candidates appreciated the use of exotoxins. Incorrect responses suggested that they digested organic material as an aid to nutrition.

(d) This question was well answered across the whole ability range. Most candidates had seen or done a similar experiment and described the method well.

Q60.

(i) Only a minority of candidates was able to perform a percentage increase calculation. The most common error was to divide the final mean amount (0.73) by the original amount (0.05), failing to subtract.

(ii) Only the more able could suggest antibodies in the mother's milk, or placental transfer of antibodies as methods. Weaker candidates frequently stated that the antibodies were inherited.

Q61.

(a) (i) Build up of immunity in the community or advances in care were examples of acceptable responses. Again, 'vaccination', unqualified, was the most common answer and, again, this received no credit.

(ii) Most candidates gained one mark for stating that a mutant form or new strain was involved. Relatively few went on to complete the explanation in terms of non-recognition by memory cells.

(b) Weaker candidates continue to confuse the actions of T and B lymphocytes. However, even these candidates know that both types of cell clone in response to infection. References to phagocytosis by T lymphocytes were, unfortunately, quite common.

(c) Few candidates read the information given and therefore answered in terms of viruses being unable to enter cells. Those who answered correctly in terms of leaving the cell could rarely explain inhibition, rather merely re-stating that it would occur.

Q62.

This question produced a wide range of marks and proved to be an effective discriminator.

(a) Answers to this question were rather disappointing, often lacking the precise details expected at Advanced level. Although some candidates referred to 'memory cells', many did not specify that these are T or B cells (lymphocytes). Better candidates did mention antibodies but they often failed to explain that antibodies previously produced were ineffective or that it takes time to produce new effective antibodies following infection by a new strain of the influenza virus.

(b) In part (c)(i), although many candidates appreciated that macrophages engulf pathogens, few candidates precisely described that the antigen is then displayed on the macrophage cell membrane. An alternative mark point credited was the role of macrophages in producing cytokinins which stimulate B lymphocytes. Part (c)(ii) was generally well answered with most candidates obtaining at least two marks. Many candidates explained that the mitochondria provide ATP and that the RER or

ribosomes are involved in protein synthesis. Although some candidates then linked protein synthesis to antibody production, only the best candidates provided a correct function of the Golgi body in terms of packaging and/or secreting proteins or glycoproteins.

Q63.

Whilst a full range of marks was seen on this question, five marks were very rarely awarded. Most candidates' powers of expression were not up to the task of explaining what they meant in part (b). Most candidates scored between one and three marks.

(a) The majority of candidates obtained this mark.

(b) Relatively few obtained the mark in part (i). Most candidates misunderstood the basic purpose of the study and wrote about vaccination (versus no vaccination) having no effect on the number of influenza cases. Many merely turned the stem of the question around and stated 'there is no difference in effectiveness of the vaccines'. More candidates scored a mark in part (ii) by writing about the rejection of the null hypothesis.

(c) This discriminated quite well. Good candidates usually obtained two marks, average candidates often failed to gain one mark for vague references along the lines of 'it not being a fair test', and weak candidates gave answers such as 'there were a different number of people in each group'.