Biology

Course Code: BIO315116

The feedback from the final examination paper was positive and seen as one that generally had a good range of questions to give the candidates a chance to show their abilities. All parts were generally well attempted by the 815 candidates who sat the Biology exam in 2016.

Suggested Marking Scheme and Comments

Suggested answers with mark allocations for each question are given along with comments on candidates' performance in the exam. Marking examiners have provided specific comments on aspects such as how the question was assessed, where candidates gained and lost marks and where candidates misinterpreted questions. Comments on the open-ended questions may necessarily be limited to general comments rather than specific details.

The suggested answers are by no means prescriptive and a number of them go into a greater detail than would be required to gain full marks. Candidates providing different but valid answers were given credit for any points that addressed the criterion and relevant to the question.

PART 1

Question 1

(a) (i) IV = Age of the subject (1); DV = rate of growth of the fingernail (1)

Majority of the candidates got 2/2 for this question. Some candidates confused the IV and DV. Some thought that the IV was the line filed onto the fingernail for measurement.

(ii) The use of the same subject (the doctor) (1) acts as a control for genetic factors that may influence nail growth (1) carried out for many years (½). Single person doing the experiment should limit experimental method differences (1).

ALSO ACCEPTABLE: A single trial is not controlled as it does not take various aspects of human physiology into consideration (1) No mention of keeping other extraneous variables the same (1) Age may have only been one factor, no mention of overall health (1). Other explanations, with justification, were given ½ – 1 mark.

Majority of candidates said that it was NOT a controlled experiment due to: single subject, lack of repetition. No mention of external factors like diet, health, exercise and work habits that could impact on nail health / growth. A few said that he could have lost his nail or even the whole thumb through injury which would have impacted on results.

Many candidates said that it was impossible to 'remove' the Independent Variable meaning that there was no 'baseline' for comparison. (a quasi-experiment or single-subject experiment)
Many candidates sat on the fence, stating that the single subject would have kept most things the same BUT the lack of repetition or mention of other variables being controlled rendered the results untrustworthy.

(b) Answer relates decrease in chirping rate (1) to decrease in oxygen concentration / air pressure / temperature / any other valid abiotic variable (1); written in correct form (1).
Example: "The chirping rate of crickets is slowed as the rate of metabolism decreases"
Must have a "cause".

If relate decrease in chirping rate to altitude, (1 ½ - 2)
If "As altitude increases, chirping rate decreases" (2)

OR

The chirping rate of crickets is slowed due to change in "any abiotic factor"

Most candidates who answered this question were able to get 2/3 marks for stating that as height above sea level increased, chirps decreased.

Some either misread the information or were confused while writing and claimed that the crickets chirped more the further up they went. That received no marks.

The great majority of candidates who received 6/7 on this question as a whole lost the final mark by not stating the abiotic factor (air pressure, oxygen level etc.) as a cause. Some candidates received a half mark for stating that there was less chirping as less crickets lived higher above sea level.

Question 2

Candidates did reasonably well on this question but very few gained full marks.

(a) Transpiration is water loss from the leaves of the plant (½) which can be measured by weighing the apparatus at the start and end of specified period (1). The water level will reduce / go down. (1).The oil prevents evaporation from the surface of the water (1) so that only water leaving through the shoot is measured (1).

Common mistakes were not including a method of measuring the water loss (e.g.: weighing the apparatus before and after, or making volume marks on the side of the flask and measuring the volume at regular intervals)

Answers that said 'change in water, or change in level' but didn't state how they would measure this, did not attract full marks. The question is specific in asking how the potometer could be used to measure water loss.

(b) (i) Shoot 1, treatment 2 upper surface covered and lower surface has most stomata therefore showing a water loss of 65 units (1) compared to shoot 2, treatment 2 where the lower surface with most stomata is covered therefore showing decrease in water loss to 18 units (1) .

Many candidates found evidence that water loss occurs through the stomata on the leaves (Shoot 1, 2nd treatment – lost 65 units). However they did not compare this to any other treatments to provide evidence that transpiration mainly occurs through stomata on leaves. The best answers compared water loss in shoot 1, 2nd treatment, to water loss in shoot 2, 2nd treatment.

(ii) For shoot 2 treatment 2 (1), water loss still occurs when only lower epidermis is covered (1).
OR
Shoot 1 treatment 2(1), reduction in water loss occurs, upper surface (which doesn't have stomata) is covered (1)

Many candidates were confused about the location of the cuticle and this made it difficult to fully answer the question. Candidates that knew that a cuticle covered the entire leaf and had read the information that a laurel plant only have stomata on the underside of the leaves easily gained full marks for this question.

Question 3

(a) To the left (or other appropriate description of direction, e.g. towards bee, inwards, towards the test tube, towards the tap (½) as oxygen is consumed by the bees (½) and the CO_2 produced is absorbed (½) the pressure inside the tube will decrease.

Some candidates referred to the size of O_2 molecules vs CO_2 molecules as being the reason that the coloured bubble would move. Some candidates referred to the heat of the water-bath causing the gases to expand and push the bubble to the right rather than the left – although this was reasonable it did not address the context of the question. Many candidates wrote O_2 as O^2. This was not penalised. In general the question was done very well with most candidates receiving at least 1 ½ marks out of 2. Very few candidates received no marks and most of those did not address the question in their response or did not attempt the question at all.

(b) To move the drop back to the right (1) / to refill the capillary with air for further experiments (1) / to reset the apparatus (1).

Many candidates related the purpose of the syringe as providing oxygen for the bee throughout the experiment, few realised that the tap being closed between the bee and the syringe prevented that from occurring. The best responses realised that the syringe was there to initially set up the apparatus or ready the apparatus for additional trials. Some candidates noted that it could be used to move the coloured bubble. The use of terms that indicated the timing of the use of the syringe, e.g., initially, was important.

In general, most candidates received (½) out of (1) for this question. Few received the full mark (1) allocated. Lots of candidates mentioned that the bees needed oxygen to breathe or they would suffocate.

(c) The distance the drop moves (½) in a particular time period / specify a time (½), e.g. distance moved in 5 minutes.

Generally, most candidates recognised the need for two measurements. More than half of the candidates recognised these measurement as distance and time. The other half had a range of options, some of them were okay if given with explanation, e.g., "amount", but others were completely inappropriate and referred to measurement not achievable given the apparatus available. Several candidates completely missed the point of the question and referred to CO_2 and H_2O increasing inside the test tube. The question stated in "the apparatus" - an important instruction to guide the type of measurements that needed to be taken.

(d) (i) Individual bees vary in many ways that may affect their rate of oxygen consumption (1) .e.g. size, activity, gender etc. (½ for using examples providing species was not the example). Obtaining an average for 10 bees may reduce the impact of these differences (1) or by reducing natural variations (½).

Many candidates mentioned the role of the bee in the hive would have an impact, (½) was given. Many candidates stated that the queen should not be used (½) because it was very different from the rest of the bee population. Half marks (½) were awarded for recognition of any of the other factors that would indicate the experiment would be improved, e.g., validity, reliability, outliers identified, averages achievable, larger source of data to work with. An additional half mark (½) was added to the above if an explanation of how it would improve the experiment, e.g., an average could be calculated (½) which would allow for a better comparison to the natural bee population (½). Several candidates pointed out that it would increase the rate at which the experiment would run and therefore would make results easier to collect or similar (1 mark was awarded).

(ii) Randomly (½) to avoid bias (½) so that factors that might have an impact on bee respiration, such as weight of bees, activity of bees, health of bees (½ for using examples) are distributed evenly for each group (½).
OR
Create groups that are matched for age, size, sex, health, (not species) etc. (1) to control these variables (1). Half marks (½) were awarded for giving an indication that they understood that having matched groups would help control the variable even if candidates didn't explicitly say "control these variables" in conjunction with the variables they had listed.

There were two main options given as possible correct answers. Most of the candidates started with randomness and then went on to explain that the nature of bees in a hive was to have different roles and therefore bees were hard to study because it was important to carefully consider what the

experimenter was actually trying to determine and select bees that would reduce variables. Many candidates DID NOT realise / relate that this part of the question had the same context as part i) and talked about the need for the bees to be of the same species – which was clearly stated in the context. A great variety of methods for collecting random / selected bees were given. Some candidates simply repeated what they had given in part d)i) for this question without success.

The nature of the question allowed for candidates to actually describe how they would actually collect the bee sample. Those that mentioned a random number generator and explained an appropriate application were given a full mark (1), those that had some other equally appropriate method related to their response were also awarded up to (1) mark or (½) mark if it was not quite possible. Candidates who said that bees should not be studied for whatever reason, e.g., ethics, endangered, were given no marks (0) because this did not address the question.

(e) Trial 3 at 25°C (½) is 7.3, but other readings are around 10 or 11 (½) it is a significantly lower rate of oxygen consumption than the other trials at this temperature (1).
OR
Trial 1 at 35°C (½) is 22.5, but other readings are around 18 (½) has a significantly higher rate of oxygen consumption than the other trials at this temperature (1).

(f) Trial 3 at 25°C: This could be due to the temperature falling (to around 20 °C) (2), or the candidate forgot to increase the temperature and left it at 20 °C (2), or some of the bees in the respirometer could have died (2), or the bees were less active (2).
OR
Trial 1 at 35°C: This could be due to the bees being more physically active (1) or the temperature rising above 35°C (1).
OR
Any other explanation that satisfactorily accounts for the anomaly.

(g) The respiration rate would continue to rise (½) following the trend shown in the table (½) or the bees' oxygen consumption may plateau (½) as other factors, such as amount of oxygen or glucose, limit cell respiration (½) or the temperature would rise even more rapidly (½) as shown by a larger increase from 35°C to 40°C (½).

It is not a good follow-up experiment as bees are unlikely to experience such high temperatures in nature (1). It is not ethical as the bees are likely to become stressed and die as the temperature is high enough to start denaturing normal proteins (1).
OR
Bee oxygen consumption might fall, as one or more bees in the respirometer die from the high temperature (1).

Answers e-g: There were quite a number of candidates who stated the most obvious errors from their own experience like tabulating the value incorrectly – writing the value for 20°C in the wrong place or failing to increase the temperature of the water bath, losing track of the time and therefore getting a higher rate. These responses were rewarded because they showed an understanding of the nature of experimentation. Some other candidates were able to analyse the setup of the apparatus and realised that if the material that absorbed the CO_2 was saturated, then a CO_2 build up would slow the movement of the drop of liquid and produce a lower value. Again if this point was well explained the candidates got their marks.

Question 4

Strengths:

- The use of twins allows the researchers to determine the relative contribution of genetics and environment on brain aging (1) as identical twins share 100% of their DNA (1).
- The study ran for a number of years (½), which is important as brain ageing is a progressive disease (½).
- Objective, quantifiable tests – e.g. neuroimaging assessments – were used to gather reliable data (1).

- Repeating the assessments every two years helped to confirm results (1).
- Used volunteers with written consent (1) and was approved by ethics committees including the Australian Twins Study. This shows that the study was properly scrutinised (1) and was unlikely to do any harm to the participants. It used volunteers (½) and was approved by ethics committees (½).
- Volunteers were from all states in Australia, which would mean a broader and more representative cross section of subjects (1).

Weaknesses

- The sample size of 623 is not particularly large for a human study (½) given the large number of uncontrolled variables (1) and would presumably reduce over time as participants died (½).
- Surveys may not produce reliable information about past behaviours, particularly in older people who may have memory problems (1) or people who were not honest about their drug usage.
- There were so many factors being measured that it would be difficult to find correlations or formulate a hypothesis for further investigation (1).
- The study can, at best, identify correlations between variables. It is not an experiment where the direct of effect of the manipulation of a variable is being measured in real time (1).

For each strength or weakness candidates must identify a factor and be specific about the rationale for why it is considered a strength or weakness.

A mix of strengths and weaknesses required.

This question was generally well done.

Most candidates were able to eloquently point out the ethical considerations of this study were a strength.

Quite a number of candidates made a valid point but did not indicate whether the point they raised was a strength, or a weakness. Some candidates suggested improvements.

The retesting every two years was often understood to mean that the experiment was repeated and this was mistakenly quoted as a strength. In this study the "every two years" is actually the sampling rate. It is imagined that the health, fitness and lifestyle test data taken every two years would be correlated with the brain health and function data and a point on a graph registered each time.

Quite a lot of candidates were concerned that because the study was on older twins that they might die and not finish their study! A few candidates were able to realise that each twin was the control for the other and in this case if one twin died they had a valid point.

Few candidates really understood or mentioned the underlying principle of a twin study as being that identical twins have the same genetic make-up and therefore one variable is controlled or fixed.

PART 2

Question 5

(a) Specificity refers to the way that each enzyme can only catalyse ONE particular reaction (1) as only the correctly shaped substrate can enter its active site (1).
OR
Specificity refers to the specific condition that enzymes operate in (1), for example, pH/temperature (½). Enzymes cannot function/are denatured outside of their specific pH/temperature range (½).

Majority of candidates gave an example to describe their understanding of *specificity* rather than explaining the term *specificity* in relation to enzymes. e.g.: "Enzymes are specific for their substrate." ½ mark for description rather than explanation. A full explanation was required for full marks. e.g.: "The shape of an enzyme's active site is a complementary fit for the shape of just one substrate molecule making it specific".

(b) The chemical reactions involved in metabolism (e.g. respiration) in bacteria require enzymes (1). If antibiotics inhibit these key enzymes, the reactions won't occur (1) and so the bacterium dies (1).
OR
Inhibitors can prevent enzymes functioning by slowing down or stopping enzyme action (1 ½) that contribute to life processes such as respiration (½) and so the bacterium dies (1).
OR
There are two types of inhibitors: Competitive and Non-competitive inhibitors (½). Competitive inhibitors compete with specific substrates in bacterial enzyme pathways (½) to slow the production of products (½), whilst non-competitive inhibitors change the shape of certain active sites (½) to prevent product formation (½). This prevents a bacterium from maintaining essential life processes (1) and so the bacterium dies (1).

Over 90% of candidates saw the word, '*inhibitors*' and immediately wrote about competitive and non-competitive inhibitors without relating them to how drugs destroy bacteria. A maximum of 2/3 was given for detailed answers explaining how these inhibitors stop enzyme pathways in bacteria. The additional mark was only gained if the candidate's response linked enzyme pathways to respiration or life processes in bacteria. Many candidates lost a single mark for not linking their answer to the question.

(c) Competitive inhibitors compete against the substrate to lock onto the active site (1). Nevertheless, some of the substrate molecules will be successful and so some product will be made (1). Non-competitive enzymes attach elsewhere on the enzyme molecule, distorting the active site (1) so that NO substrate molecules can attach (1).
OR
Competitive inhibitors reduce the rate of reaction (1) but if substrate concentration is increased, that effect is overcome (1). Non-competitive inhibitors are not affected by substrate concentration (1) as they prevent the formation of enzyme-substrate complexes by altering the shape of the active site (1).

Vast majority of candidates knew the differences between competitive and non-competitive inhibitors but quite a number had difficulty explaining that an increase in the substrate will partially overcome the effect of a competitive inhibitor but have no effect on a non-competitive inhibitor, thus making non-competitive inhibitors more effective in stopping enzyme pathways.

Many candidates also incorrectly assumed that because a non-competitive inhibitor changes the shape of the active site that the enzyme is therefore denatured, being an irreversible process. They assumed that one non-competitive inhibitor could then leave a denatured enzyme and move to the next enzyme to denature it, making non-competitive inhibitors more effective than competitive inhibitors in stopping enzyme pathways. Credit was not given for this.

Question 6

(a) Photosynthesis produces glucose(½) it is used in respiration (½). Excess / left-over glucose is converted to plant tissue / results in net growth (1).

Therefore, the greater the rate of photosynthesis as compared to respiration, the more glucose available for plant growth(1).

Most candidates could describe that photosynthesis produces glucose (chemical energy), and that respiration uses it and, that if photosynthesis were maximised then respiration was minimised, then there would be more plant growth for the farmer. Gaps in their understanding included that it was gases / water that were the purpose of the process not glucose production / consumption. So for example the purpose of photosynthesis is to make oxygen for use in respiration and that the purpose of respiration is to make carbon dioxide (and or water) for photosynthesis. So if respiration is minimised the water and/or oxygen production for use in photosynthesis will be limited (the closed system idea).

Many candidates only referred to glucose being used for either energy or tissue. Very few identified both. If they used the word energy rather than glucose they got confused when explaining respiration. e.g. Photosynthesis captures light to produce energy which is used in respiration to produce energy.

(b) (i) More CO_2 increases rate of photosynthesis (1), as CO_2 is a necessary ingredient (½) whilst not changing respiration rate and so there is net growth(1). Increased chance of substrates (CO_2 and H_2O) colliding with enzymes to produce product / glucose (1).

The majority of candidates could say that carbon dioxide is a necessary input for photosynthesis and that increasing the rate of CO_2 would increase yield (½ mark for each point, ½ mark extra if they did this very clearly demonstrating depth of understanding). Very few mentioned respiration rates not changing resulting in net growth or the role of increased substrate increasing the chance of collision. (1 ½ or 2 was the most common mark). There was some confusion thinking that because the stem mentioned both temperature and carbon dioxide that the question pertained to both rather than just CO_2.

(ii) Increasing the temperature increases respiration rate (1), but rate of photosynthesis will not increase (1) because light intensity is a limiting factor (1), so rate of photosynthesis is too low to replace respiratory loss (1). 3 marks max.

Candidates on the whole struggled with this question. Very few got full marks. They mostly got distracted with the effects of temperature on rate of photosynthesis leading to many repetitive theories about the enzymes required for photosynthesis being denatured. If they only gave this response they got 0. If this was just one element of some other aspects discussed then credit was given.

Many could identify that low light intensity reduced the rate of photosynthesis and hence yield.

Water balance affected by Temperature was the other most common explanation for the reduced yield. This included everything from increased transpiration or evaporation rates leading to reduced photosynthesis because of lack of water. The opening / closing of stomata due to light variation and corresponding changes in the gas / water exchange rates reducing photosynthesis were common ideas.

Many candidates got focused on one factor i.e. temperature or low light and failed to make any comment on the relationship that may affect yield.

Question 7

This question was very well done overall with the vast majority of candidates scoring full marks.

(a)

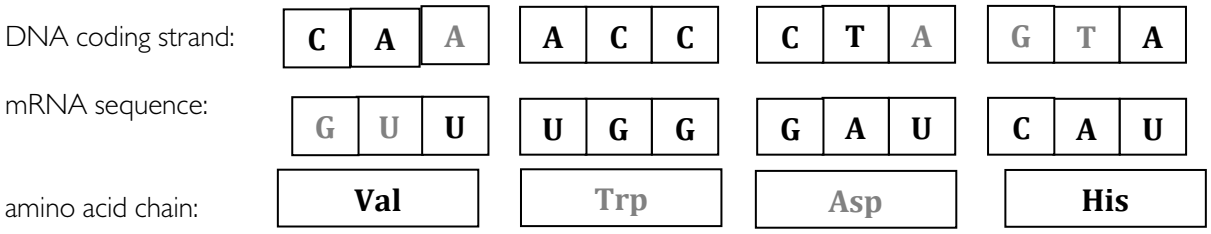
Statement	DNA replication	Transcription
Involves mRNA synthesis	✗	✓
Requires free nucleotides	✓	✓
Involves complementary base pairing	✓	✓

Small errors occurred where candidates confused the process of transcription with translation.

(b) Number of **nucleotides**: 12 000 (½)
Explanation: 2500 guanine bases means 2500 cytosine bases (½); 3500 thymine bases means 3500 adenine bases (½) so total bases is 12000 (½). 1 deoxyribose molecule for every base (½).

Credit was given if candidates answered with 6000 deoxyribose molecules and justified their answer.

(c)



1 mark for each amino acid correctly transcribed and translated.

Some candidates coded for the amino acid from the DNA rather than the mRNA.

Question 8

This question was attempted by virtually all candidates.

(a) Protein (½), DNA (½)

Most candidates got at least ½ mark for this part, with the majority opting for protein. About half the candidates got both answers and it was rare for candidate to suggest compounds other than protein and DNA.

(b) Glycogen is a polymer of glucose (½) so all the monomers are the same (½). However, there are 20 or so different amino acids (½) which can be joined together in different orders to form different protein/polypeptide chains (½).
OR
Proteins have lots of different functions, whereas glycogen is just for the storage of glucose (1 – 1 ½ marks depending on detail provided.

1 mark for discussion of protein molecules and 1 mark for discussion of glycogen molecules.

This was generally well done. Candidates who didn't relate their answer to the concept of polymers being made up of monomers could still score up to 1 ½ marks for considering functional differences between the molecules. A number of candidates suggested that glycogen was a monosaccharide, or a lipid. In order to gain full marks, answers needed to address both sides of the question – i.e. protein molecules vs. glycogen molecules.

(c) ATP is not "used up", it can be replenished (1).
ADP + Energy + P ↔ ATP – as an equation or described in words (1)
Glycogen is broken down to glucose (½) and the glucose is respired to produce more ATP (½).
2 marks max.

This part was the least well done for this section. Many candidates simply described the process of DNA replication, or suggested that the bacterium used energy / ATP from its host. If it was suggested that bacteria produced additional ATP via cell respiration, they were awarded 1 mark even if they went on to identify the site of this respiration as mitochondria (which are not present in prokaryotic cells).

(d) Lipids consist of a small number of fatty acids units attached to a glycerol molecule (1) whilst proteins consist of a large number of amino acid units joined together (1). If no mention of bonding/joining/attaching of molecules, max of 1 ½ marks.

Energy/ATP is needed to join molecules (1).

Protein synthesis involves lots of steps (e.g. transcription, translation, movement of molecules within the cell), all of which require energy. (1).

Proteins are large/complex molecules (½); lipids are small/simple molecules (½). If mention the makeup of proteins (AAs) and lipids (fatty acids + glycerol) (½).

1 mark for discussion of protein molecules and 1 mark for discussion of lipid molecules.

This part was generally well done. The most common reason that candidates lost marks was that their answer didn't discuss both protein and lipid molecules. Quite a few candidates thought that amino acids needed to be made (from scratch) by protein synthesis, whereas lipids (or their component parts) enter the body from foods.

(e) 1 mark for any two of the following:
Movement, active transport of substances across a membrane, internal transport within the bacterium, (initial steps of) cell respiration, reproduction, growth.

Whilst growth can only be achieved by the production of new molecules, it was accepted as a valid answer. However, DNA replication and protein synthesis were not accepted as they are more clearly identifiable as involving "making molecules". Endocytosis and exocytosis were not accepted as they cannot occur in bacteria due to the presence of a cell wall. However, some credit was given if these terms were used in conjunction with the term "active transport". Many candidates had lost sight of the fact that this question was asking about a bacterial cell and so gave responses such as – temperature regulation, muscle contraction, pumping of a contractile vacuole, so they can run for long periods.

PART 3

Question 9

This question was answered well.

(a) 1 mark for every 3 correct – for a total of 4 marks and ½ mark for two correct.

	BACTERIUM	PRION	VIRUS	PROTIST
PATHOGEN	*A*	*E*	*B*	C
Needs a supply of food	✓	✖	✖	✓
Reproduces by splitting	✓	x	✖	x
Respires	✓	✖	✖	✓

This was generally well done. The most common error was identifying D as the bacterium. Other errors included stating that protists reproduce by binary splitting, prions respire and bacteria do not respire.

(b) Plant cell wall is rigid like a cardboard box (½) and is made of the same stuff – cellulose! (½).
Animal cells have a flexible cell membrane (½) and many can move (½).

Maximum of 1-2 marks for describing if this is an appropriate description

Plant and animal cells have similar organelles – examples (1 max)
Plant and animal cells perform similar functions – examples (respiration, protein synthesis, reproduction) (1 max)
Maximum of 2 - 3 marks for similarities

BUT – there are some important differences:

- Different organelles – e.g. centriole, chloroplasts (1 max)
- plant and animal cells perform some different functions – examples – photosynthesis, osmoregulation (via contractile vacuole), endo/exocytosis (1 max)

Maximum of 2 - 3 marks for differences

While many candidates commented that it was appropriate to liken the rigid cell wall of plant cells to a cardboard box, very few realised or referred to the movement of the cell membrane within the cell wall. Several stated that the membrane was attached to the cell wall, so that no movement was possible.

A common error was stating that plants contain a contractile vacuole. Some candidates thought that cell walls are a barrier to movement into and out of cells.

Similarities and differences in organelles between the two types of cells were well covered, as was the fact that plant cells carry out photosynthesis whereas animal cells do not.

Marks were lost by failing to point out common functions, such as protein synthesis and cellular respiration. Several candidates stated that animal cells respire to produce energy, whereas plant cells rely on photosynthesis.

Generally, ½ mark was allocated for a summary statement as to the appropriateness of the description given, but only if at least 2 marks had been gained by evidence given to support this. Candidates could gain up to 1 mark for a well-considered summary.

Question 10

(a) Eukaryotic (½) as they have membrane-bound organelles (½) such as mitochondria (must give an example) (½) OR a nucleus that is surrounded by a membrane (1).

(b)

Letter	Organelle	Role in synthesis or secretion of mucus
F	*Mitochondrion (1/2)*	*Provides the energy (½) required to unzip DNA/assemble proteins (½)*
D (1/2)	Golgi Apparatus	*Refines the protein (by adding sugar to it) (½) and packages it into a vesicle (1)*

(c) They provide a larger SA (1) so that secretion (by exocytosis) will be faster (1)

Question answered very well. Common errors included thinking the cell was 20um in size (rather than using the scale bar to correctly ID the size (length and width). This was not penalised.

Most candidates did not realise the Golgi could be known as an apparatus or a body; in addition they were unaware that the Golgi only modified protein with carbohydrate and did not make proteins. This resulted in the loss of ½ mark.

Many candidates were unable to show how the role of each organelle was associated with the synthesis and secretion of mucus. Those that wrote the descriptions from the information sheet were gained only a ½ mark. Every candidate received some marks for this question. Most candidates were able to identify an increase in surface area as significant.

Question 11

Most candidates attempted all parts of this question however there were a number of common mistakes and around half of candidates received less than 50% of the allocated 13 marks.

(a) (i) The cells will swell up (½) due to the net movement of water INTO the cells (osmosis) (½) as they are in a weak/hypotonic solution (½).

AND

The cells will become paler/lighter in colour/the surrounding water will become red (½) as the red dye will diffuse OUT of the cells (½) because the concentration of the dye is greater inside the cells that outside (½)

Many candidates misread this question and gave individual answers for each 'cell' or assumed the diagram was showing what had already happened after a few hours. This meant that a number of candidates gained 0 marks for this question.

(ii) D (1)

Osmosis and diffusion will be fastest

- at the highest temperature (30 °C) (½) because molecules have more energy / will move faster (½).
- where there is a the largest difference in concentration / largest concentration gradient between the cell and the external solution (1)
- in the cells with the largest SA:Vol (½) which is provided by the "extensions" (½)

Those that chose cell 'D' correctly generally scored very well, while a number of candidates incorrectly chose cell 'E' or 'F' and gave the incorrect reason that big cells and weak concentrations diffuse faster.

(b) (i) The surrounding water has a low solute concentration (1) meaning that more water moves into the Amoeba by osmosis (1), so more "beating" of contractile vacuole required to remove the excess water. (1)

Was generally well answered with most candidates acknowledging that lower solute outside the Amoeba will result in a net input of water which needs to be removed. Some candidates simply re-wrote the question and gained 0 marks.

(ii) Line drops down to 0 and then flattens out (1).

(iii) Solute concentration reaches and exceeds that of months 0 – 3 when CV is not functioning (½) and becomes Hypertonic to the Amoeba (½). During this time the contractile vacuole does not need to work as excess water is not moving into the Amoeba so graph flat lines at 0 contractions (1) NOTE: line mustn't go below zero – negative output not possible!

The graph was poorly drawn even though many candidates gave good explanations in part (iii) for how the vacuole contractions would change. Over 3 quarters of candidates drew the graph below the level of 0 and a number even said the vacuole would suck in water from outside of the Amoeba.

Question 12

(a) Mitosis (1) as the amount of DNA in the daughter cells is the same as in the parent cell (1)

To gain full marks candidates had to refer back to the 'parent cell'; many were give ½ here as they referred back to the original number of chromosomes.

(b) D is when the chromosomes/chromatids are separating (1), being pulled by spindle fibres (1).

½ mark was awarded for 'C' or 'D' but to gain full marks they had to refer to the 'separating' to chromosomes by the spindle fibres. Many referred to the lining up of chromosomes but did not link the function of the shortening spindles to separating chromosomes.

(c) Similarity: the chromosomes replicate (1) OR the original and replicate chromosomes are separated into different daughter cells (1).

Differences: in mitosis in eukaryotes, the chromosomes are attached to spindle fibres (1) and are pulled to opposite ends of the cell as the fibres contract (1).
Any other valid similarity/difference.

Candidates answered this well in a descriptive manner.

PART 4

Question 13

The answers that were accepted involved:

Adaptation (½) how it contributed to efficient gas exchange (½) in animals (½) and in plants (½) for each of three adaptations.

	Lungs (Max 3 marks)	Leaf (Max 3 marks)
Large SA :V	Large surface area of alveolus. (½). Exchange of gases occurs across surfaces, so the larger the surface area, the more rapidly exchange will occur. (½).	Large surface area (½) of cavity inside leaf to maximize gaseous exchange. (½) OR Many long thin leaves with numerous stomata to increase surface area for exchange (1).
Moist Environment	Gases dissolved in water (1/2) are more exchanged more readily into the cells (1/2). Animals do this by having their lungs inside their body (1/2) or by having a moist ling to the lungs (1/2)	Similarly the inside of the leaf is kept moist (1/2) due to the transpiration of water vapour out of the stomata.
Thin exchange membrane	Thin membranes (½). This reduces the distance molecules must diffuse to reach or leave the blood, maintaining a high concentration gradient and so increasing efficiency of exchange. (½).	Cavity inside leaf in close proximity to the cells/air spaces between the spongy mesophyll cells (½) maintains a high concentration gradient and ensuring efficient internal gaseous exchange. (1)
Maintenance of a concentration gradient OR short distance for gases to diffuse	Rich blood supply in capillaries (½). The large number of capillaries maintains blood flow close to alveoli thus maintaining a high concentration gradient. This results in high levels of exchange of molecules into and out of the blood. (½)	The close proximity between air spaces and cells using the gases for photosynthesis along with the numerous stomata on their surface, (½) that open to allow exchange of gases, in particular CO_2 in & O_2 out. (½)

A number of candidates did not attempt the question. There were a number of candidates who wrote about villi and microvilli increasing the surface area in the lung as well as candidates who wrote that plant leaves were only one cell thick. Candidates commonly mistook gases for nutrients and so were discussing glycolysis in the lung.

Overall candidates either gave answers relating to surface area, small distances for gases to diffuse and an ability to maintain a concentration gradient without relating this to the lung or the leaf gaining them up to 3 marks; or they wrote vaguely about lungs and leaves having air spaces, openings to control gas exchange or the ability to regulate gas exchange breath more deeply after exercise or open / close stomata without relating this to why there may provide efficient gas exchange.

Few candidates linked the "theory of adaptations like increased surface area with, how that provided efficient gas exchange and then linked this to adaptation like alveoli in animals and air spaces the spongy mesophyll or having numerous stomata on the leaves" for each of three adaptations.

Question 14

(a) Organ **P**: stomach (½)
Organ **Y**: pancreas (½)

Many candidates wrote gallbladder instead of pancreas.

(b) Animal B (½) has a large caecum (X) (½) where microbial digestion (½) of cellulose (½) occurs, cellulase (½).

Many candidates crossed out B to A and justified their answer by talking about the importance of caecum. The explanation was right, but the image chosen was not correct.

(c) Animal C's diet is most likely made up of simple foods that need little digestion (1)- e.g. nectar, blood (½) as the gut is short and unspecialised (½).

Many candidates wrote carnivore because it was easier to digest. Many candidates associate "liquids" as easier to digest, not specifying what is in the liquid.

Question 15

(a) In the sauna, the participants are gaining heat from the environment (1). They must lose this heat in order to ensure their core temperature does not increase (1). If the sauna was moist, they would not be able to sweat (1) to lose this heat. Perspiration is the most rapid way of losing heat (1). A dry environment maintains a concentration gradient for water from the skin to the air (1).

As the temperature in the sauna is close to the boiling point of water, sweat may burn the participants. (½)
If the sauna was moist, this would provide a breeding ground for bacteria and put participants at risk of infection (½)
max. 3 marks

This part was not done well by a significant proportion of candidates. Common errors included:
sweating is increased in humid environments (not true) so scientists are at risk of dehydration.
The humidity in the sauna will fill the lungs with water which will interfere with gas exchange,
discussing the dangers of having sweat freeze when scientists go outside or humid air freezing in the lungs (the question specifically asks about how harm is minimised inside the sauna, not outside).

No marks were awarded for statements along these lines.

(b) Aerobic (utilising oxygen) (½) respiration (½) produces heat (1) which replaces lost heat (1) (and therefore maintains body temperature. (NOT: "To keep warm")

Generally done well. The most common error was for candidates to state that thermoregulation was the cellular process within cells, and then dump the negative feedback model into the answer space. Half a mark may have been awarded for this if respiration or oxygen consumption were referred to in the answer.

(c) Any one of:

Vasoconstriction of blood vessels near the surface of the skin (½) can reduce heat loss (1) to the cold environment by reducing blood flow to the skin (½). Shivering/increased muscle activity (½) increases respiration (½) and so generates heat to replace heat that is lost (1).

Piloerection (½) goose bumps that make hair stand on end (½) traps warm air (½) to decrease temperature gradient/heat loss (1).

Other accepted answers

Shrinkage of the male genitalia (½) to reduce surface area (1) which minimises heat loss to the environment (½).

Generally done well.

(d) B (½). Less O_2 consumption = lower respiration rate (½) as experiences less heat loss (1) due to body shape (sphere = low SA:Vol) (1) and more insulating fat (½). Therefore, less heat (from respiration) needed to replace lost heat (½).

The key to this question was to understand the concept of relative oxygen consumption (litres per hour per kilogram) as opposed to absolute (litres per hour) oxygen consumption. Many did not demonstrate understanding of this concept. A significant number of candidates selected 'A' as the endomorphic response to decreased temperature. Where they did, candidates almost invariably attributed increased oxygen uptake to the fact that endomorphs are larger individuals and therefore have more cells that must be supplied oxygen. Half a mark was awarded for this.

Many also thought the oxygen uptake response was due to running around the South Pole, so the endomorph would represent response 'A' as he would be less fit than the mesomorph or the ectomorph. Again half a mark may have been awarded but no extra credit achieved.

Those candidates who selected response 'B' generally achieved at least half marks or higher as their explanations showed relevant understanding.

(e) Clothing would gather moisture from perspiration while in the sauna and instantly freeze when worn outside in the sub-zero temperatures (1). Ice in direct contact with skin could lead to frostbite/"freezer burn" (1).

A minority of candidates gained 1 or more marks for this question. The most common response was to say that the underpants will cause constriction of blood flow to the legs, or that wearing underpants will result in uneven thermoregulation around the body and thus cause harm. Both of these gained no credit.

Question 16

Most candidates answered this question with the majority of candidates fairing quite well and found it straight forward with about 75% of candidates gaining 5 ½ marks or more. A common mistake that was made in this question was that the values they gave in part a) were contradicted in their explanations for part b) and c).

(a) Glucose: Q = 0.1 (½), R = 0.0 (½)
Protein: P = 0.0 (½), R = 0.0 (½)

Most candidates scored full marks for this part.

(b) Glucose is a small molecule which is filtered into the Bowman's capsule (½). All glucose is actively reabsorbed (½) into the bloodstream in the convoluted Proximal Tubule (½) as it is needed in the body for cellular respiration (½).

Most candidates correctly answered this question but a high proportion of candidates failed to get full marks because they didn't give enough detail on where in the nephron it was being absorbed, how it was being absorbed and why it was being absorbed.

Some candidates fell into the trap of just reciting the numbers in the diagram and not explaining what was happening, these candidates only managed to score a maximum of 1 mark.

Other candidates that failed to obtain full marks only stated that it would be reabsorbed before point R (collecting duct) and not going into greater detail than what was given to them in the diagram.

(c) Proteins are too large (½) to be filtered into the Bowmans Capsule (½), therefore protein is only found in the blood and not filtered through to the nephron.

Most candidates scored full marks for this question.

(d) A long Loop of Henle (½) increases the surface area of the loop which increases the re-absorption of water back into the blood (1). This means that the mouse is excreting more concentrated urine (½), enabling it to survive in an area where there is little water available.(½).

Candidates fell into the trap of writing too generally about what an increased loop of Henle would do and didn't give any detail about how absorption is related to surface area. The better answers wrote about increased the loop of Henle having a greater concentration gradient and the urine having an increased concentration because the body was reabsorbing more water.

(e) (i) B (½)
(ii) C or D (½)

Many candidates misidentified the stimulus as 7. Many candidates could not correctly identify the effectors.

(f)

Stimulus	Change in concentration of sodium ions in blood (½)
Receptor / transmission	Pituitary gland – sends message via 1 and 2 to kidney tubules and the collecting ducts (1)
Effector	Changes reabsorption of Sodium ions in the Kidney tubules, and Changes permeability of the collecting ducts via ADH (½).
Response	Concentration of blood is restored to normal (½)
This is an example of negative feedback (½)	

Most candidates showed that they had a reasonable understanding of how feedback loops work and what factors are important but only a limited number of candidates scored full marks for this section as many failed to include that it was a negative feedback loop. Some candidates did not refer to the diagram and merely wrote down what they knew about the water balance feedback loop these candidates only scored a maximum of 2 marks.

To obtain full marks candidates needed to refer to the diagram and provide additional information to support their explanation.

PART 5

Question 17

This is the inflammatory response (½). Once the skin is breached / broken by the pin, it allows pathogens / bacteria access to the tissue inside (½).

Damaged cells / presence of pathogen stimulate mast cells to release histamine (½)that increase vasodilation of capillaries (½) near wound site. Delivery of blood, plasma and cells to wound site increases (½). The capillaries also become more permeable/ 'leaky' (½) allowing neutrophils and macrophages (phagocytic cells) and plasma to leave the capillaries and enter site of infection (½). This causes swelling, redness, heat and pain (½). Here the phagocytic cells phagocytose the pathogen/bacteria (½). Increase in temperature at wound site also more likely to kill pathogen / bacteria by increasing chemical reactions to promote healing (½). Swelling restricts movement of wound site to promote healing (½).

Macrophages release cytokines that attract immune system cells / other WBC's (½) to the wound site (chemotaxis) and activate cells involved in tissue repair.

Platelets from blood release blood clotting proteins at wound site in an attempt to prevent more bacteria entering site (½).

Inflammatory response continues until pathogen/bacteria is eliminated and the wound is repaired (½).

This question allowed candidates to display knowledge, with many candidates giving many of the points above over and beyond the 4 marks limit. As a result, the majority of candidates answered this question very well.

However, many candidates misinterpreted the question and described the diagrams as the 1st, 2nd and 3rd line of defence instead of describing the inflammatory response. Candidates only gained marks here if they were able to describe the process of phagocytosis within the context of 2nd line of defence.

Candidates also did not gain marks if they simply took words from the diagrams with no real explanation of the processes involved. Candidates needed to describe what the chemical signals were, the significance of vasodilation and increase in permeability of blood vessels, why phagocytes and fluid move in to the damaged tissue and what phagocytosis is.

There was some confusion in terminology for example: the blood vessels become more 'diluted' instead of 'dilated'. Also that histamine caused blood 'cells' to be more permeable instead of blood vessels.

Question 18

(a) The injection contained dead/inactive pathogen (½). On initial exposure to an antigen there are no antibodies present (½). However, the antigen triggers a specific immune response stimulating B cells to proliferate into plasma cells and memory cells (½). Plasma cells start producing antibodies but this proliferation takes several weeks (1) to build up enough antibodies to fight antigen. At 30 weeks the amount of antibodies decrease as the antigens have been destroyed by the body (½). The level of antibodies remains at a low level/ does not return to '0' as memory cells (B and T memory cells) are still present to respond to re-infection (½).

This question was not answered well by the majority of candidates as candidates failed to make reference to the graph. An information overload was made by many candidates regarding the humoral and cell mediated response with many detailed answers about B cells, helper T cells, cytokine release, antibody production etc. etc. with absolutely no reference to the amount of antibodies that were present in the person injected with the antigen. Candidates only gained 1 ½ marks in this circumstance.

Marks were also not awarded to candidates who just described the graph without any explanation. Many candidates thought that the antigen was not recognised for several weeks by the immune system and this was why antibodies took so long to build up. Most candidates ignored that the level of antibodies decreased after 30 weeks but did not return to 0 and so lost marks as a result.

There was some confusion in terminology with many candidates confusing the terms 'antigen' and 'antibody', with candidate making statements such as "the injection of antigen caused the amount of antigen to increase in the body" or that the 'antigens' attacked the 'antibodies.'

(b) Antibodies are produced more rapidly (½) and in greater quantity (½) due to presence of memory cells (memory B and T cells) (1) produced during the primary exposure to the antigen.

This question was answered well by the majority of candidates with a large percentage gaining the full 2 marks. Marks were lost if candidates failed to mention memory cells and their ability to produce antibodies rapidly and to a higher level.

Many candidates simply stated there would be an increase in immune response with no reference to antibodies so marks were lost as a result.

A large percentage of candidates thought that there would not be an increase in antibodies or change in immune response as there were memory cells ready to fight antigen. Some candidates also thought the antigen would be stored in the memory cells which is incorrect.

(c) The antibodies provided artificial passive immunity (½) to the antigen, that is, the person's specific immune system was not triggered/stimulated (½) and as a result no memory cells were produced to replenish or replace the antibodies after a time period (1) so antibody levels decrease.

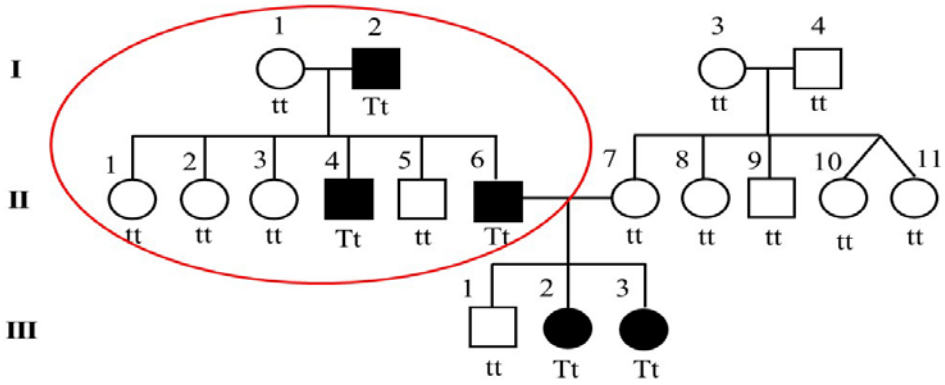
Candidates either understood this question or did not. A large percentage of candidates were given '0' marks as they simply stated that the 'antibodies had no purpose in the body and just died' with no connection to immune system or passive immunity.

Candidates did not gain full marks if they simply stated this was an example of artificial passive immunity – they needed to explain what this was, that is, where the specific immune system was not triggered.

Question 19:

Most candidates attempted this question.

Pedigree key



Circled area refer to part (b).

(a) Let T = webbed toes (dominant); t = normal toes (recessive)

II-6 is Tt as he had an unaffected mother (tt) (II-7 is unaffected and therefore tt (½ for correctly identifying parents – directly or in Punnett square)

		II-6	
		T	t
II-7	t	Tt	tt
	t	Tt	tt

(1 for correct Punnett square)

Offspring: Genotype: ½ Tt; ½ tt
Phenotype: ½ webbed toes; ½ normal toes

Therefore, the chance of having an affected child is 50% (½)

Overwhelming proportion of candidates got full marks in this part with most providing an accurate Punnett square. Candidates that made mistakes generally had not read the question that webbed toes was autosomal dominant: either they treated webbed toes as autosomal recessive or sex-linked. A small proportion lost ½ mark for identifying the father as tt and mother as Tt.

(b) If it was X-linked and dominant, individual I-2 would be X^AY (1) and individual I-1 would be X^aX^a (1). ALL of his daughters would inherit the X^A from him and be affected (1) and his son (II-6) would NOT inherit the X^A from him (1).

		I-2	
		X^A	Y
I-1	X^a	X^AX^a	X^aY
	X^a	X^AX^a	X^aY

(1 for correct Punnett square)

Again, this part was generally very well answered with most candidates correctly identifying the correct area of the pedigree and the putative genotypes of the father and mother under sex-linked dominant inheritance. Candidates who provided Punnett squares almost invariably had these correct. Candidates lost marks for not specifically identifying individuals from the pedigree (e.g. referring to "all daughters in generation II") or not using appropriate symbols to demonstrate their understanding.

(c) The population arose from a small "founding" population (½) that may have had a higher than average occurrence of this allele (½). This population was largely genetically/reproductively isolated from other populations (little immigration into the population) (½). This has meant that there has been considerable inbreeding (½) and a smaller gene pool (½), so there is a much higher than average probability of mating between two people carrying the recessive allele (½), which have a ¼ chance of producing an affected offspring (½).

This was the part of the question that was answered most poorly with few candidates getting more than 1 out of 2. Most candidates identified the impacts of inbreeding and / or limited gene flow with external populations but almost none recognized the impact of the founder population or talked about allele frequency.

(d) Webbed toes is not a lethal disease (1) and so sufferers may marry other sufferers (or unaffected people) and have children, some of whom will inherit the disorder (½). However, children with ALM die before they reach reproductive age (1) and therefore don't hand the allele onto their offspring (½). The change in allele frequency (½) is due to the lethality of the ALM homozygote (½).

There was a binary response to this part with candidates generally getting no marks or getting close to full marks. The most common mistake was to ascribe the changing allele frequency to the system of inheritance (autosomal recessive vs. dominant) rather than the lethal nature of ALM preventing reproduction in homozygotes. A lot of candidates confused the frequency of the condition (webbed toes or ALM) with the change over time (webbed toes constant, ALM declining).

Question 20

(a) Due to a mutation [1 mark]

Many candidates answered this question stating Natural Selection, which in the context of this question was inaccurate.

(b) (i) Strain A: R^LR^L (½ mark)
Strain B: R^HR^H (½ mark)
F_1: R^HR^L (½ mark)

This question was well answered by the majority of candidates who attempted the question. A few candidates incorrectly swapped the answer for strain A and strain B - this may have been due to misreading the information on the question or not understanding the supporting graph.

(ii) Neither allele is dominant / they are co-dominant / incompletely dominant (½). Flies with both alleles survive for a time period (6 hours) that is intermediate / an average / a moderate amount between the Strain A (2 hours) and Strain B (10 hours) survival times (½), suggesting that both alleles are being expressed (½).

Many candidates did not receive full marks for this section. Most candidates could identify that the allele was neither, dominant or recessive and showed an understanding that the allele being expressed was either incomplete or co-dominant thus both alleles would be expressed. However, candidates often did not link this back to Figure 2 to support their answer, in which duration of survival was being depicted.

(c) The F_2 generation, derived from crossing R^HR^L and R^HR^L would have the following proportions and phenotypes with a link/explanation of results in Figure 3.

- ¼ (25%)- high resistance (½)therefore survive up to approximately 10 hours (½)
- ½ (50%)- intermediate/moderate resistance (½), therefore survive until 6 hours (½)
- ¼ (25%)-low resistance (½), therefore only surviving approximately 2 hours (½)
- Which matches the proportion of phenotypes shown in Figure 3 representing the percentage of F_2 flies surviving over time (1 mark)

Some credit was given to candidates who added in the genotype only- but as the question was not fully answered, full marks could not be gained. (R^HR^H /R^HR^L /R^LR^L).

The majority of candidates did not receive full marks for this question, mostly due to them putting in the genotype within their answer and not stating a phenotype at all. (Some credit was given for the genotype as it demonstrated candidates understood the cross and the resulting generation produced).

Again many candidates did not refer to Figure 3 when answering the question to explain the results of this cross. Many candidates were quite vague as to the proportions and candidates found it difficult to state a phenotype for R^HR^L- being intermediate / moderate resistance.

Question 21

(a) Individual TB bacteria vary in their resistance to the antibiotic (1) due to mutation and/or meiosis (1). The allele for resistance was already in the population before the antibiotic was first used. (1). The antibiotic acts as an artificial selection agent, selecting those bacteria with the 'fittest phenotype' (1). When the antibiotic was used more of the least resistant bacteria would have been killed (1), leaving more of those with greater resistance to produce the next generation (1). Resistance to the antibiotic is genetically determined, (1) so the more resistant bacteria passed on their resistance to their offspring, resulting in an increase in the frequency of the genes for resistance in the population (1). In each generation there would still be variation in resistance, but with an overall increase in resistance while the antibiotic was being used (1). Any new mutation or meiotic combination which produces more resistance will be favoured if antibiotic use continued (1).

Five good well explained points - 5 marks. Should cover variation in population, sometimes from a mutation, resistance bacteria survive while most are killed, antibiotic is the selective pressure, resistance as an inherited characteristic passed on , change of frequency of alleles over many generations.

Many candidates did not realise that the question was about artificial selection and consequently scored little or no marks. Some candidates gave a detailed account of how bacteria could gain active immunity, completely wrong.
Some common misconceptions included;

- Antibiotics produce antibodies.
- Antibiotics work in the same way antibodies do.
- Bacteria can become immune to antibiotics by developing memory cells.

(b) Ensure that the complete course of antibiotics are taken (1) – stopping early may leave some bacteria with mild-resistant alive, which would be more difficult to treat in the future (1).
Use a combination of different antibiotics (1) – a bacterial strain susceptible to one antibiotic may be killed by a different one (1).
Avoid overuse or unnecessary use of antibiotics (1) so bacteria have less chance of becoming resistant (1).
Develop a vaccine (1), so bacteria are killed by person's immune system (1).
Develop new antibiotics (1) to kill the more resistant strains (1).
Isolate people infected with TB (1), to stop the development / spread of resistant strains (1).
Use good hygiene (1) to stop the development / spread of resistant strains (1).

This part was generally answered well, as there are many possible correct answers.