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Paper 9700/11
Multiple Choice

Question Number	Key	Question Number	Key	Question Number	Key	Question Number	Key
1	D	11	A	21	A	31	B
2	B	12	C	22	C	32	D
3	A	13	B	23	B	33	B
4	A	14	A	24	A	34	D
5	D	15	B	25	D	35	C
6	C	16	B	26	B	36	A
7	D	17	B	27	C	37	C
8	D	18	D	28	A	38	C
9	C	19	A	29	C	39	C
10	B	20	C	30	A	40	C

General comments

Ten questions (**1**, **9**, **11**, **12**, **16**, **21**, **26**, **34**, **36** and **37**) were found to be relatively easy and eleven questions were relatively more difficult (**3**, **4**, **6**, **8**, **18**, **22**, **27**, **28**, **29**, **32** and **33**). Many of the challenging questions focused on misconceptions or specific detail of plant and human physiology or histology. Many of the more difficult questions also required candidates to read the question, and each option, very carefully before making their final choice.

Comments on specific questions

Question 3

Almost all candidates knew that the smooth endoplasmic reticulum and vesicles are required by cells for the synthesis and secretion of lipids. Some candidates did not realise that energy from mitochondria is also required and thus opted for **C** instead of the correct option, **A**.

Question 4

Candidates were asked to use an electron micrograph to identify the organelles in a cell and decide which points about the cell were correct. All three points about the cell were correct (option **A**). Some candidates selected options **B** or **C**, both of which excluded the idea that the cell contained organelles that could be used to make antibodies. These candidates may not have associated the production of antibodies with protein synthesis.

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Question 6

This question asked candidates to find the option where the steps to identify a non-reducing sugar were correctly sequenced. More candidates knew that the correct sequence was given in option **C** than those who left out the heating step after adding the dilute hydrochloric acid, opting instead for **B**. Others opted for **A**, the method to identify a reducing sugar.

Question 8

Candidates were required to identify the structure that had a covalent bond that joined monomers together to form a biological polymer in eukaryotes. The correct option, **D**, would form a polynucleotide. The most common incorrect answer was option **C**. This structure could show part of a triglyceride, which is not a polymer.

Question 18

This question required careful reading to work through an osmosis investigation. Many candidates correctly identified which solution was distilled water and which was the salt solution. Some candidates did not realise that the cells that did not burst would have been root hair cells, the only plant cell on the list, and opted for **C** rather than the correct option, **D**.

Question 22

This question relied on mathematical skills and an understanding that the number of base pairs in the mRNA will be three times the number of amino acids in the associated protein. Most candidates did this calculation and found that 6000 base pairs was one of the relevant numbers; some thought that this was the length of the introns, opting for **C**, rather than the correct option, **D**.

Question 27

Some candidates may have misread this question, opting for **A**, rather than selecting the only feature of xylem vessel elements in the list that helps to reduce resistance to water flow, **D**.

Question 28

Many candidates correctly selected option **A** as the mechanism that causes water to move from the root hair cells to the endodermis. Similar numbers of candidates incorrectly thought that osmosis moved water through the apoplast (option **B**) or active transport moved water into the endodermis (option **C**).

Question 29

Some candidates selected option **B**, rather than option **C**, to describe the changes that occur as a carbohydrate is moved into a sink. These candidates understood the relationship between the water potential and volume in the sieve tube elements but did not know the correct direction.

Question 32

Almost all candidates knew that the point shown on the graph of the blood pressure changes in a cardiac cycle is when the aortic semilunar valve opens; fewer realised that when this valve opens, the atria will be filling (option **D**), rather than emptying (option **C**).

Question 33

Although slightly more candidates worked out that a carbon dioxide molecule must pass through a cell surface membrane at least twice to travel from the tissue fluid into the blood plasma (option **B**), some candidates opted for more (options **C** and **D**) or less (option **A**) times than this. Some candidates may have counted the cell surface membranes of some cells more than once or missed one of the cells in the pathway.

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Paper 9700/12
Multiple Choice

Question Number	Key	Question Number	Key	Question Number	Key	Question Number	Key
1	C	11	D	21	B	31	C
2	A	12	C	22	D	32	D
3	A	13	B	23	A	33	A
4	C	14	B	24	D	34	A
5	B	15	C	25	B	35	D
6	B	16	D	26	D	36	A
7	B	17	A	27	C	37	C
8	D	18	A	28	B	38	C
9	B	19	D	29	C	39	D
10	C	20	A	30	B	40	C

General comments

Nine questions (**5**, **10**, **14**, **24**, **25**, **27**, **30**, **36** and **39**) were found to be relatively straightforward and ten questions were relatively more difficult (**9**, **15**, **18**, **20**, **23**, **29**, **32**, **34**, **35** and **38**). Many of the questions that challenged candidates required the interpretation of experiments or graphical information. Some of the questions from the topic on transport in mammals also identified knowledge that was less secure for some candidates.

Comments on specific questions

Question 9

This question asked candidates to consider which reactions would be catalysed and inhibited by an unfamiliar enzyme that digests chitin. Almost all candidates correctly used the information to deduce that the enzyme would inhibit hydrolysis of glycosidic bonds. Some thought that it would catalyse the hydrolysis of peptide bonds (option **D**) rather than glycosidic bonds, the correct option **B**. These candidates were unaware that the same enzyme could not be involved in both the inhibition of some glycosidic bonds and the catalysis of other glycosidic bonds. This highlighted misunderstandings between substrates, active sites and bonds.

Question 15

This applied question asked candidates to find the graph that showed the data for an investigation on the effect of pH on amylase activity. Most candidates correctly opted for graph **D**. The most common incorrect

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answer was graph **A**. Whereas the data was correctly plotted in this graph, the *y*-axis label did not match the units for that axis.

Question 18

Almost all candidates knew that proteins and glycoproteins in cell surface membranes can recognise messenger molecules and allow cell-to-cell recognition; some did not know that they can also allow cells to bond together to form tissues. This meant that some candidates opted for **D**, rather than **A**.

Question 20

This question on osmosis required candidates to decide which cells would swell most when dandelion scapes were placed in the solution with the highest water potential. Many candidates deduced from the information in the diagram that showed that the outer cells had thicker walls than the inner cells, that the inner cells would swell most (option **A**). A few candidates thought the highest water potential would have a minimal effect on the curvature of the scape, opting for **B** and **C** in similar numbers.

Question 23

Most candidates knew that a centromere attaches daughter chromosomes to the spindle fibres, but some candidates thought that less than 4 of the 16 cells in the photomicrograph were in telophase, opting for **C** rather than the correct option, **A**.

Question 29

A small majority of candidates knew that there is a negative pressure in the xylem and a negative water potential in root hair cells in transpiring plants (option **C**). There were a number of candidates who thought that one or both of these measurements would be positive.

Question 32

Most candidates knew that veins would carry blood with lower pressure than arteries. Some of the less well-prepared candidates opted for the pulmonary vein (**C**), rather than the vena cava (**D**), as the blood vessel with the lowest pressure.

Question 34

Candidates were required to identify the cause of the Bohr shift in actively respiring cells in this question. Some candidates incorrectly thought this was due to the speed of oxygen release from oxyhaemoglobin (option **D**), rather than a change in the affinity of haemoglobin for oxygen caused by the release of protons (option **A**).

Question 35

Almost all candidates knew that the left ventricle has the thickest walls, excluding option **C.** Some thought that the left atrium would have a thicker wall than the right ventricle (option **B**). Others knew that the ventricles would have thicker walls than the atria, but ranked the two atria the wrong way around, opting for **A** rather than **D**.

Question 38

Most candidates knew that tropical and subtropical environmental conditions and the vector required for transmission are factors that affect the global distribution of malaria. Some candidates thought that effective vaccines have already eradicated the disease in many countries and opted for **B**, rather than the correct option, **C**. Although effective vaccines are now available, eradicating malaria from many countries has not yet been achieved.

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Paper 9700/13
Multiple Choice

Question Number	Key	Question Number	Key	Question Number	Key	Question Number	Key
1	B	11	A	21	D	31	C
2	B	12	A	22	D	32	C
3	C	13	A	23	C	33	C
4	C	14	B	24	D	34	D
5	B	15	C	25	B	35	A
6	B	16	D	26	B	36	B
7	B	17	A	27	A	37	A
8	C	18	D	28	C	38	B
9	A	19	A	29	D	39	A
10	B	20	C	30	A	40	B

General comments

Ten questions (**1**, **9**, **14**, **15**, **25**, **28**, **34**, **36**, **37** and **38**) were found to be relatively straightforward and nine questions relatively difficult (**2**, **6**, **13**, **16**, **17**, **22**, **23**, **24** and **29**). Most of the least challenging questions focused on knowledge with understanding. A number of the most challenging questions highlighted misconceptions in the topics on enzymes and nucleic acids and protein synthesis.

Comments on specific questions

Question 2

Many candidates answered this question correctly, selecting option **B**. The most popular incorrect answer was option **C**. These candidates knew that the ribosomes isolated from cells in a sucrose density gradient would carry out protein synthesis but had not considered that there would also be ribosomes in the fractions containing mitochondria and chloroplasts.

Question 6

Almost all candidates knew that after the radioactively labelled amino acids had been introduced into the cell they would move from the rough endoplasmic reticulum, through the Golgi body to the secretory vesicle. A significant minority of candidates incorrectly thought that after entering the secretory vesicles, the amino acids would be found in the cytoplasm, opting for **B**, rather than realising that the cytoplasm would be the first place they would be found (option **D**). Those candidates who incorrectly chose **B** had not taken into account that the question stated that the tracheal cell would use the amino acids to make mucus, which

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would mean that exocytosis out of the cell would occur after the glycoproteins were found in the secretory vesicles.

Question 13

Although most candidates knew that the unsaturated fatty acid molecule described in the question would contain 29 hydrogen atoms in its tail (option **A**), some candidates thought that the answer was 31 (option **B**). These candidates had not taken into account that both carbons associated with each double bond will have one less carbon, but that the last carbon in the tail would have 3, rather than 2 hydrogen atoms.

Question 16

Most candidates knew that statements 2 and 3 about the results from the amylase investigation were correct conclusions. However, some of these candidates opted for **A**, rather than the correct option, **D**. Without data for temperatures lower than 50 °C, and within a narrow range either side of the expected optimum temperature, no conclusion about the optimum temperature for the enzyme can be made.

Question 17

Almost all candidates knew that a change in substrate concentration would be involved in the regulation of an enzyme-catalysed reaction. A few candidates incorrectly thought that either a change in enzyme concentration or inhibition by the final product in the reaction would not be involved. These candidates opted for **C** and **D** respectively, rather than the correct answer, **A**.

Question 22

Almost all candidates knew that the fourth statement about the mitotic cell cycle was correct, i.e. that the same quantity of DNA is distributed to the nuclei at the end of cell division. However, some candidates thought that DNA replication occurs during mitosis (statement 1) and did not know that daughter cells will have the potential to express the same genes as the parent cells (statement 3). This meant that they opted for **B**, rather than the correct option, **D**.

Question 23

This question showed a photomicrograph of a cell in metaphase (option **C**), shown as a transverse section through the equatorial plate. Many candidates incorrectly assumed that this was a longitudinal section through the cell and thought that the cell was in telophase. The chromosomes are not shown gathering at opposite poles; instead, they are clearly arranged in a ring. Many candidates found it difficult to visualise the stages of mitosis in three dimensions or had not considered that the cells could be sectioned in different planes.

Question 24

Some candidates incorrectly opted for **B**, rather than the correct option, **D**. These candidates thought that the purine labelled J is adenosine, even though this term refers to the nitrogenous base attached to ribose.

Question 29

This question required candidates to find the statement that described the pathway taken by a water molecule travelling from the soil to the xylem. Although slightly more candidates opted for the correct statement (**D**), similar numbers of candidates selected either option **A** or **B**. Option **A** is incorrect because there are symplastic routes for water, other than to travel between adjacent phospholipids. Option **B** is incorrect because xylem vessel elements do not contain cell surface membranes or cytoplasm and so no osmotic movement into xylem vessels is possible.

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Paper 9700/14
Multiple Choice

Question Number	Key	Question Number	Key	Question Number	Key	Question Number	Key
1	D	11	D	21	A	31	B
2	C	12	D	22	D	32	D
3	A	13	D	23	D	33	A
4	C	14	B	24	A	34	B
5	A	15	B	25	A	35	B
6	A	16	C	26	D	36	C
7	C	17	C	27	C	37	C
8	D	18	C	28	A	38	A
9	B	19	C	29	B	39	B
10	B	20	D	30	B	40	D

General comments

In this paper ten questions (**2**, **18**, **26**, **28**, **29**, **32, 34, 35, 36,** and **37**) were found to be relatively straightforward and nine questions were relatively more difficult (**1**, **4**, **7**, **12**, **14**, **22**, **33**, **39** and **40**). Where many candidates had selected the wrong option, this was linked with misreading the information either in the question or in the options. The term active site was used in two of the more challenging questions (**14** and **40**). This highlighted common errors associated with using this term.

Comments on specific questions

Question 1

Almost all candidates knew that mitochondria would be visible using a high power light microscope and the centrioles would not be visible. However, some candidates incorrectly opted for **C**, suggesting they did not know that starch grains would also be visible.

Question 4

This question required candidates to consider information about the cell structures present in four different types of cell. Although three of the cells (Q, R and T) could be found in plants, some candidates incorrectly opted for **B**, thinking that only two of the cell types were found in plants.

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Question 7

Almost all candidates knew that proteins contain double bonds between carbon and oxygen. Some candidates incorrectly thought that glucose, rather than glycerol, also contained these double bonds.

Question 12

Although neither of the two features of collagen in the table contribute to its strength and elasticity (option **D**), there was no obvious pattern in the options chosen by the candidates.

Question 14

Although many candidates identified option **B** as the correct statement about the induced-fit hypothesis of enzyme action, option **C** was a popular wrong option. This statement described the shape of the active site changing to become the same, rather than complementary, to the substrate.

Question 22

Most candidates knew that DNA polymerase moves along the original DNA strands in opposite directions and excluded options **A** and **B** from their choice. Many other candidates opted for **C**, rather than **D**, suggesting that they did not know that the new strands form in the 5' to 3' direction.

Question 33

Although more candidates chose **A** as the correct statement describing the Bohr shift, many candidates opted for **B**. An increase in affinity of haemoglobin for oxygen that occurs when oxygen concentration rises is not a description of the Bohr shift.

Question 38

Most candidates knew that no memory cells being produced was the reason for the delay in developing long-term immunity (option **A**). The candidates who opted for **C** needed to read carefully to the end of the question to be aware that this was about developing long-term immunity.

Question 40

Many candidates opted for **C** as a statement that described a feature of monoclonal antibodies that allows them to treat specific diseases. This statement was incorrect because antibodies do not have active sites because they are not enzymes, instead they have antigen-binding sites. The correct option was **D**; they can carry toxic chemicals.

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Paper 9700/21
AS Level Structured Questions

Key messages

It is important that candidates look carefully at the command words in a question to make sure the answer they write fully addresses the question asked. **Question 3(b)** asked candidates to explain the results collected during an experiment using a colorimeter. Most candidates described the trend in the data but only the strongest candidates suggested reasons explaining why this trend was seen.

Candidates should read their answer together with the question stem to make sure that their response does not repeat only the information already provided as part of the question. For example, **Question 6(a)(iv)** asked candidates to provide an explanation of how hydrolysing bonds in peptidoglycan leads to the destruction of bacterial cells. Many candidates only repeated the information in the question.

It is important that candidates use the information presented in diagrams and photomicrographs that accompany questions in their responses. **Question 4(a)** and **Fig. 4.1** introduced candidates to copepods. There was a scale bar to indicate the size of these organisms in the photomicrograph of a copepod in **Fig. 4.1**. The strongest responses used this information when answering **Question 4(b)**. **Question 4(a)(ii)** asked candidates to draw the monomer that forms when chitin is hydrolysed. **Fig. 4.2** showed part of the structure of chitin, which candidates needed to use to answer the question accurately. A common incorrect answer was to draw α-glucose monomers, suggesting that candidates had not recognised the need to use the information in **Fig. 4.2.**

General comments

Knowledge that a phospholipid has a hydrophilic phosphate head and hydrophobic fatty acid tails allowed many candidates to suggest correct answers to **Question 1(d)** and an understanding of the reasons for the Bohr shift allowed candidates to answer **Question 2(b)** successfully.

In **Question 2(c)(ii)**, the strongest answers suggested that candidates had taken time to plan their extended response. Events in the cardiac cycle were clear and correct, used the appropriate terminology and were in sequence. Candidates were able to use the abbreviation AVN in their response as this was present in the question. Some candidates mistakenly used SAN instead, demonstrating the importance of checking responses for accidental errors.

It is important that candidates read each question carefully and pay particular attention to the command words and/or instructions that are given. Although **Question 3(b)(ii)**, **Question 3(c)**, **Question 4(b)** and **Questions 5(b)(i)** and **(ii)** all required candidates to analyse data, the actual questions required different types of answer. Here, some candidates gave a description of the results or stated a pattern shown when the question asked for an explanation, and some gave explanations where a description was required. In **Question 3(c)**, some gave explanations of the results shown in **Fig. 3.3** rather than explaining how the results supported the conclusion made by the candidate. Hence, many candidates explained how a non-competitive inhibitor works to reduce the rate of a reaction, which was not answering the question posed.

Candidates should be able to recall accurate definitions for key biological language. Many candidates were unable to recognise the definition of a gene in **Question 6(a)(i)**. Many candidates were also not able to name the strand of DNA that is used to synthesise mRNA in **Question 6(a)(ii)**.

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Comments on specific questions

Question 1

(a) This question assessed knowledge of the structure of the cell surface membrane. Most candidates were able to name the structures in **Fig. 1.1**. There were more errors in naming structures **A** and **B** than for structure **C**. The most common incorrect answer for **A** and for **B** was phospholipid. Other incorrect names included triglyceride and fatty acid.

(b) The majority of candidates were able to recognise that molecules moving by facilitated diffusion must travel through structure **P** in **Fig. 1.1**. Stronger candidates were able to interpret the diagram and recognise that the carbohydrate chains on the glycolipid and glycoprotein identified the outer surface of the cell, so the arrow through structure **P** must point downwards to show movement into the cell. The most common incorrect response showed the arrow travelling upwards through structure **P**. Some candidates showed molecules moving through the phospholipid bilayer.

(c) Many candidates were able to state that the fluidity of the membrane would increase with an increase in the proportion of unsaturated fatty acids in the membrane. Fewer candidates were able to give reasons for this increase. The most common correct explanations included knowledge of the 'kink' in the fatty acid chain and the effect of this on the packing of the phospholipids in the bilayer. Weaker answers described changes in the permeability of the membrane rather than fluidity. Some candidates wrote about the effect of cholesterol on the fluidity of the membrane which did not address the question.

(d) Candidates needed to apply their understanding of the structure of proteins to **Fig. 1.1**. Stronger responses showed an understanding that the amino acids at position **1** were adjacent to the hydrophobic fatty acid chains of the phospholipids in the bilayer so these amino acids were hydrophobic, or the amino acids in position **2** were opposite the hydrophilic phosphate heads and were therefore most likely to be hydrophilic. Weaker responses simply repeated the question stating that the two amino acids would have different properties, without providing any further detail. Some candidates misinterpreted the question and tried to describe differences in functions of the amino acids, such as different roles in transport through the membrane.

Question 2

(a) Stronger responses often stated that an oxygen molecule binds to haemoglobin. Weaker responses incorrectly identified the numbers of oxygen molecules transported, suggesting for example that each haem group transports 4 oxygen molecules. Some candidates confused oxygen atoms with oxygen molecules. Some weaker responses only restated the question by explaining that oxygen is transported by haemoglobin. Few responses recognised that iron is found in the haem group and only the strongest responses explained oxygen binding to a ferrous ion.

(b) This question required candidates to apply their understanding of the Bohr shift to the unfamiliar context of the effects of hyperventilation. The strongest responses described the reaction between carbon dioxide and water in the red blood cells to produce carbonic acid, the dissociation of carbonic acid and the subsequent formation of haemoglobinic acid. Most responses which described these reactions also linked back to the question by referring to a decrease in carbon dioxide concentration and therefore less carbonic acid and haemoglobinic acid formation. Weaker responses described these reactions without making reference to the decrease in carbon dioxide. Some responses confused haemoglobinic acid with carboxyhaemoglobin. Some candidate only stated that the decrease in carbon dioxide concentration would increase haemoglobin's affinity for oxygen and needed to explain why the change in affinity occurred.

(c) (i) This question required candidates to study **Fig. 2.1** and identify blood vessel **X** as an elastic artery. Most candidates recognised that blood vessel **X** was an artery, which transports blood at high pressure. Stronger candidates were able to expand their answer to describe the high proportion of elastic fibres in the wall. Weaker candidates simply described the structure of the wall of a general artery rather than an elastic artery, stating that smooth muscle and elastic fibres were found in the wall without reference to the high proportion of elastic fibres. The strongest answers included further explanation of the importance of the high proportion of elastic fibres, such as the stretching of elastic fibres preventing the blood vessel bursting. Weaker responses referred to prevention of bursting which was not sufficiently precise. Candidates needed to link this to the stretching of the elastic fibres. Some candidates incorrectly described the artery as pumping blood.

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(ii) Most candidates found this question challenging. The strongest responses described impulses travelling from the atria to the ventricles. Weaker responses used insufficiently precise language to describe the impulse such as an 'electrical pulse', 'electric signal' or 'wave' or 'signalling wave'. Most stronger candidates were able to describe the role of the AVN in providing a delay in the impulse passing from the atria to the ventricles. The strongest responses developed this idea and linked the delay to the need for the atria to empty before the ventricles contracted.

Some candidates confused the role of the sinoatrial node (SAN) and the AVN and described the AVN as the pacemaker. Some candidates confused the location of the Purkyne tissue, describing the impulse traveling in the Purkyne tissue through the atria, while others confused the Purkyne tissue with the valves in the heart. Stronger responses recognised that the Purkyne tissue carries the impulse to the base of the heart so that the ventricles contract from the base upwards.

Question 3

(a) Generally, there was a good understanding of the lock-and-key hypothesis and the induced fit hypothesis. The most common correct similarity between the two hypotheses was to describe the substrate binding to the active site. Weaker responses that did not mention the active site but simply made reference to the substrate binding to the enzyme which was not sufficiently accurate. Most candidates who gained credit for the difference between the two hypotheses described the change in shape of the active site occurring in the induced fit hypothesis, with some describing how this shape change made the substrate complementary to the active site. Weaker responses stated that there was a change in the enzyme but did not refer to the active site, or the idea of shape, or complementarity.

(b) (i) This question was answered correctly by the majority of candidates, who were able to recall that iodine solution remains orange when no starch is present. The most common incorrect answers were colours related to tests for other biomolecules such as blue, which is the colour of biuret solution and of Benedict's solution. Red was also seen, which is the colour obtained when a solution of reducing sugar is heated with Benedict's solution. Although the text provided the information that extract **E** contained no starch, some candidates gave blue-black or black as the colour of the iodine solution.

(ii) To answer this question successfully, candidates needed to assimilate information about an unfamiliar enzyme-catalysed reaction and then apply their understanding of the use of the colorimeter to the described experiment. Most candidates described the relationship shown on the graph, but the question asked for an explanation of the results. Some responses recognised that this increase in absorbance was due to an increase in the synthesis of starch by the enzyme as time progressed. The strongest candidates linked the increase in absorbance with each successive sample to the increasing intensity of colour obtained after addition of iodine solution to the sample. Weaker candidates made no reference to the enzyme and simply described starch synthesis.

(iii) Candidates needed to use the information about the enzyme-catalysed reaction given at the start of **Question 3(b)** to answer this question successfully. The strongest responses identified that this reaction would go in the opposite direction or described this by making reference to the breakdown of starch. Weaker responses tried to explain the change in absorbance by suggesting the phosphate ions directly affected the absorption of the solution or the activity of phosphorylase. Some weaker candidates suggested that variables such as temperature had changed. A few candidates incorrectly suggested that the phosphate ions acted as an enzyme inhibitor.

(c) Generally there was a good understanding of non-competitive inhibition of an enzyme. Most candidates were able to identify the reduction in activity of phosphorylase as evidence that caffeine was acting as an inhibitor. Many candidates were able to develop this further by recognising that V_{max} was not reached in the presence of the inhibitor, with the strongest responses going further by stating that this was shown because the plateau occurred at a lower enzyme activity. A few candidates used data appropriately to quantify this difference, quoting 190 arbitrary units as the V_{max} without caffeine and 90 arbitrary units with caffeine. Some candidates misread the scale on the graph and gave these values as 80 arbitrary units and 180 arbitrary units.

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Question 4

(a) (i) This question was answered correctly by the majority of candidates, who identified the glycosidic bond between the two monomers forming part of a chitin molecule. The most common incorrect response was to identify the $NHCOCH_3$ group on one of the two monomers.

(ii) Candidates needed to use the diagram of part of a chitin molecule as a starting point to answer this question. Stronger candidates were able to apply their understanding of hydrolysis reactions to the unfamiliar scenario of the hydrolysis of chitin. These candidates successfully recognised that the glycosidic bond they had identified in **Question 4(a)(i)** needed to be broken and that the atoms from the water molecule that is required for a hydrolysis reaction should be added so that two identical molecules would be produced. It was only necessary to draw out one monomer. A common incorrect answer was to draw an α-glucose or β-glucose molecule. Weaker candidates drew other monomers such as amino acids. Some candidates who recognised that the molecule shown in **Fig. 4.2** needed to be separated did not copy the structure correctly.

(b) This question required candidates to apply their understanding of how cholera is transmitted to a study that used a simple water filter to reduce cholera transmission. Most candidates were able to state that filtering water through folded fabric reduced the transmission of cholera. Many were also able to recognise that some *Vibrio cholerae* passed through the fabric, which explained why cases of cholera were still occurring after filtering. Only the strongest candidates linked the reduction in cholera cases to a reduction in copepods in the water after filtering. They were able to use the scale bar on the photomicrograph to deduce that most of the copepods would be larger than 20 μm and would therefore be filtered out of the water which was passing through the fabric. Some candidates suggested that larger particles containing bacteria, such as faecal matter, were removed by filtering. A few candidates successfully applied their knowledge to suggest that cholera cases in people using filtered water could be the result of other sources of bacteria such as contaminated food.

(c) (i) The majority of candidates were able to describe one change in behaviour that a person can make to help prevent a serious case of cholera. A wide range of suitable ideas were given from washing hands more frequently to not eating raw food in the area where the cholera outbreak has occurred. Some candidates suggested oral rehydration or antibiotics should be given. Weaker responses simply stated hand washing, and needed to develop this idea further to answer the question fully.

(ii) This question assessed knowledge of active transport. Candidates had to interpret the information in the question stem and recognise that the membrane protein described was using ATP and was therefore likely to be a carrier protein involved in active transport. The most common incorrect answer was to suggest that this protein was an antigen which affected the ability of the immune system to identify the resistant bacteria. These candidates had perhaps confused the idea of immunity and the idea of resistance to antibiotics.

(iii) Stronger candidates recognised that antibiotics are more likely to be misused, which would lead to the evolution of resistance. Some gave examples of misuse of antibiotics, such as not finishing the prescribed course. Only the strongest were able to develop this idea and link the evolution of resistance to antibiotics to specific mutations that must occur. These candidates understood that more mutations would be needed for immune evasion to a vaccine as pathogens have multiple antigens on their surface. Weaker responses described an immune response to a pathogen without linking it to vaccines, or omitted reference to immune evasion when describing differences between the primary and secondary immune response.

Question 5

(a) (i) Most candidates answered this question correctly. Water was the most common correct answer. Incorrect answers included sucrose, oxygen and cytoplasm.

(ii) Many candidates were able to identify lignin as the name of the substance and most spelled this correctly. The most common incorrect spelling was ligning. Common incorrect responses included cellulose and chlorophyll.

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(b) (i) Candidates were required to carry out analysis of the data in **Table 5.1** and then draw conclusions from the data using knowledge of transpiration. Most were able to identify the relationship between temperature and the rate of transpiration. The strongest candidates expanded this idea, linking it to a higher rate of diffusion of water vapour out of the leaf. Weaker responses described loss of water rather than water vapour which was not sufficiently precise. Some candidates recognised that at higher temperatures the rate of evaporation of water would be higher but needed to link this to the site of evaporation, the walls of the spongy mesophyll cells. The strongest responses linked the higher rate of evaporation to increased energy owing to the higher temperature. Weaker responses incorrectly tried to link the increased transpiration to other factors such as increased light intensity.

(ii) Most candidates were able to suggest a difference in structure between the two leaves. Some candidates confused the two species of leaf and linked a xerophytic feature to *Triticum aestivum* rather than *Gossypium hirsutum,* highlighting the importance of candidates checking their answers carefully. Candidates needed to clearly link a described feature to one of the two named plant species.

(c) (i) Candidates needed to apply their understanding of the mitotic cell cycle to the unfamiliar scenario of how nematodes disrupt this cycle. The most common correct idea was that cell G would have more than one nucleus. Although it was not necessary to also give an explanation, some candidates stated that without cytokinesis the cell would not divide. Some of the weaker responses repeated the question, stating that cells had not gone through cytokinesis, without developing this further. Some candidates showed an understanding of the term cytokinesis by stating that cells that undergo this process divide to produce two new cells. These responses were not sufficient, as candidates needed to state how cell G would differ from these cells.

(ii) Stronger candidates identified that the nucleus of a cell that had been through endoreduplication would contain more chromosomes than a cell that had not. Some candidates suggested that the cell would contain a larger nucleus. Some weaker responses stated that the nucleus would contain many DNA molecules, which was insufficient as candidates needed compare the two cells by stating a clear difference.

Question 6

(a) (i) The stem of the question described a gene in the context of DNA that codes for an enzyme in a macrophage. Only the strongest candidates were able to interpret this description in order to identify the correct term. The most common mistake was to select a term related to protein synthesis, such as ‘codon’, ‘RNA polymerase’ or ‘amino acid chain’. Some candidates stated that the term was a DNA strand, which was not sufficiently accurate.

(ii) Few candidates were able to name the strand of DNA used to synthesise mRNA. The most common incorrect answers were ‘sense strand’ and ‘leading strand’.

(iii) Most candidates correctly identified the ribosome as the organelle where translation of mRNA takes place to produce lysozyme. Incorrect answers included the nucleus, mitochondria and Golgi apparatus.

(iv) Many candidates recognised that the hydrolysis of bonds in peptidoglycan would cause a weakening of the bacterial cell wall or that hydrolysis would lead to osmotic lysis. The strongest responses linked these two ideas together. Weaker responses repeated the question, stating that the hydrolysis would cause destruction of the bacterial cells without any explanation as to why this would happen. Some candidates stated that water would be needed in the reaction, demonstrating an understanding of the term hydrolysis, but did not address the question which asked how the reaction led to destruction of bacterial cells.

(b) (i) This question asked candidates to explain one specific adaptation of alveoli, which was how the cells lining the alveoli are adapted for gas exchange. Many candidates described general adaptations of alveoli, such as large surface area, large number of blood capillaries, and walls that are one cell thick. Some incorrectly referred to a thin membrane. Stronger responses recognised the importance of the flattened cells but only the strongest candidates linked this to short diffusion distance. Weaker responses linked this to a steeper concentration gradient.

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(ii) Few candidates gave strong responses to this question. Some candidates recognised that elastic fibres stretch during inhalation and others stated that elastic fibres protect the alveoli from bursting; few linked these ideas together. The strongest candidates described the recoil of elastic fibres to expel air from the lungs. Some candidates referred to the elastic fibres both stretching and recoiling but not all went on to link this to the reason why these processes occur in the wall of the alveolus.

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Paper 9700/22
AS Level Structured Questions

Key messages

Question 1(a) asked candidates to explain the difference between a cilium and a microvillus. In cases such as this, where no restrictions on what should be included are stated in the question, candidates should consider structural differences as well as functional differences.

Candidates should write out the full scientific term as it appears in the syllabus when stating the term for the first time in a response and then abbreviate thereafter if required. For example, **Question 1(c)(ii)** required blood pressure, rather than bp to be used in the response and **Question 1(e)(ii)** required rough endoplasmic reticulum, rather than RER or rough ER to be stated. Similarly, full terms were required in **Question 6(a)**, where some candidates used LA and LV to indicate the left atrium and left ventricle, or the AV valve for the atrioventricular valve.

Care should be taken when distinguishing between a disease-causing organism, or pathogen, and the disease that it causes. In **Question 2**, some candidates wrote about drinking water or food or faeces containing cholera, when they should have referred to the pathogen, or the bacterium, or *Vibrio cholerae*.

General comments

Some candidates showed a good command of the syllabus and produced complete responses that included appropriate scientific terminology. Most candidates attempted to answer all items. Some candidates who showed good knowledge and understanding of the syllabus topics could have improved their responses by taking more time to read questions carefully and to check their answers.

In **Question 1(b)**, many candidates misread the question and based their answer on mucus in the gas exchange system instead of in the digestive system. Similarly, in **Question 5(b)**, some answered the question by explaining why a structural feature of a leaf is modified in a xerophyte rather than how it is modified. In **Question 6(a)**, only some candidates answered the question in a concise manner and wrote about events occurring only in the left side of the heart. Many wrote about double circulation and/or control of the cardiac cycle and needed read carefully the instructions given and focus their responses on the question asked.

Candidates should be able to recall the correct spelling of the names of the different species of pathogen causing the infectious diseases listed in Topic 10 of the syllabus. In **Question 2(a)**, candidates needed to spell correctly the name of the pathogen that causes cholera.

In **Question 3(d)**, some candidates could have benefited from checking their diagram of the ring structure of α-glucose. The diagram drawn by many was correct except that they had not added the hydrogen to carbon 5.

Candidates were asked to outline similarities and differences in **Question 4(a)** and needed to address both parts of this question. Some answers were very well organised, often with side headings being used to show the similarities or differences. Some other responses were constructed in such a way that it was difficult to discern whether the descriptions given were trying to outline a similarity or a difference. Candidates should plan their responses to make sure that their ideas are clearly set out.

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Comments on specific questions

Question 1

(a) Overall, there was greater knowledge shown by candidates about the features of a cilium than about a microvillus. Many knew that a cilium contains microtubules arranged in a '9 + 2' pattern. Some stronger responses gave more detail and explained that this was due to nine doublet microtubules surrounding a central pair of singlet microtubules, with a few giving information about dynein arms. Some successful responses wrote about the microfilaments or actin filaments of a microvillus. The ability of cilia to move mucus was frequently stated. Those who mentioned that a microvillus was involved in the absorption of products of digestion needed to also reference an increased surface area to volume ratio. Some weak responses stated that a microvillus contained cells, while others thought that the microvillus had the same function as the cilium.

(b) Most answers concentrated on the protective role of mucus and a range of correct ideas were given. Some candidates understood that this question was about mucus in the intestines and correctly suggested that this helped the movement of the gut contents through the system. Here, it was not enough just to state 'it lubricates'.

(c) (i) Most knew that blood vessel **X** was an arteriole. There were several different incorrect spellings given.

(ii) The strongest responses to this question explained that blood arriving at the capillary network has a high hydrostatic blood pressure. Many either stated the cause as 'high pressure' without mentioning blood or 'hydrostatic pressure' without prefacing this with high. Stronger candidates noted this as an example of ultrafiltration and gave correct examples of the substances that were filtered, also noting that substances could exit via the endothelial pores or fenestrations of the capillary. Some of these explained that the larger plasma proteins would remain in the capillary while smaller proteins would be able to leave. Some candidates could have improved their response by describing the formation of tissue fluid and describing the substances that exited the capillary, rather than describing the contents of tissue fluid, which did not answer the question.

(d) Many candidates were able to apply their understanding of the main ideas of cell signalling to answer this question about an unfamiliar cell-signalling molecule, GLP-1. Some candidates showed a very good understanding of the subject matter. Others recalled that cell-signalling molecules bind to receptors on cells, and a number knew that this involved complementary binding. Some candidates incorrectly termed the cell surface receptor as an antigen. Weaker responses gave confused accounts, stating that GLP-1 released a cell signalling molecule or that GLP-1 had the receptor.

(e) (i) All the stages of mitosis in the correct sequence were given by the majority of candidates. Most spelled each stage correctly and incorrect spellings, when seen, tended to be for anaphase and telophase, for example 'anophase' and 'telephase'.

(ii) The most obvious cell structures in the Paneth cell in **Fig. 1.2** were the many large vesicles. Given the first bullet point in the question, many correctly stated that they were Golgi or secretory vesicles that would leave the Paneth cell by exocytosis. Candidates who wrote about mitochondria needed to explain a relationship between the ATP produced by these organelles and the function of the cell in production and secretion of peptides and proteins.

(iii) It was sufficient to identify the Paneth cell as being differentiated or specialised, or to give the reverse argument for the intestinal stem cell. Some candidates explained that the intestinal stem cell could differentiate into the Paneth cell, and this was acceptable. It was not quite enough to just explain the different functions of each, or to describe how they would contain different cell structures.

Question 2

(a) For the causative pathogen of cholera, many gave a correct spelling of *Vibrio cholerae*. Common incorrect spellings were *Vibro* or *Vibreo*, and *cholera* or *cholerea*.

(b) Stronger responses used accurate terminology and the correct scientific terms and focused on addressing the two approaches recommended by the World Health Organisation stated in the

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question. Weaker responses used terms that were incorrect or not precise, such as 'cholera' for pathogen, or 'dirty' or 'polluted' water instead of contaminated water. Some showed an understanding of the route of transmission, and others correctly stated that this was an example of faecal-oral transmission. Many considered washing hands as practising preventive personal hygiene and gave more detail. Some wrote about 'clean' hands, which was not sufficient. There were some very vague answers that gave general points about how providing access to safe drinking water and practising personal hygiene would prevent disease. These needed to be qualified with examples and more detailed explanations. Very few candidates explained that these two approaches would help to break the transmission cycle of the disease.

(c) (i) Many candidates applied their knowledge of artificial active and artificial passive immunity to complete **Table 2.1** correctly. Row 1 was least well answered. A common error was to state 'dead antigen' as a component of a vaccine that causes an immune response, as antigens are not cellular. Quite a number gave pathogen as the component but needed to qualify this with 'attenuated' or 'weak', or 'dead' to show understanding that the antigens for the immune response would be present but not any components that could cause the disease.

(ii) This question was well answered by many candidates. A common error was to state that the hybridoma cell would have the feature of uncontrollable division from the myeloma or tumour cell. Weak responses stated that the antibody would be fused to a myeloma cell or gave a general account of an immune response that included T-lymphocytes and/or memory cells. Some stated a stem cell instead of a myeloma cell.

Question 3

(a) The strongest candidates gave very straightforward differences that showed an understanding of why genes are different, usually citing different lengths, different nucleotide sequences and coding for different polypeptides or proteins. Many knew that the genes coded for different proteins. Weaker candidates stated that genes are different proteins. Some missed the information that gene *MCM6* coded for a protein that was not involved in lactase synthesis and incorrectly stated that *MCM6* only contained introns or coded for a protein that inhibited lactase. Others suggested a difference was the lack of introns in gene *LCT*, but this was not stated in the provided information.

(b) There were some excellent, detailed explanations of the relationship between a transcribed strand and a primary transcript and between a primary transcript and messenger RNA. These reflected a good understanding of the process of transcription. Other responses had the greatest difficulty relating the transcribed strand to the primary transcript. Many needed to make it clearer that the transcribed strand was the DNA template strand or that the primary transcript was a complementary copy, rather than an exact copy, of the transcribed strand.

(c) Most candidates stated 'substitution' or 'base substitution' for the mutation that causes lactase persistence. Some wrote about changes to amino acids, which was not relevant to a mutation within an intron.

(d) Most candidates knew the structure of alpha glucose and could confirm this from **Fig. 3.1**. However, the hydrogen was frequently omitted from carbon 5 of the ring structure.

(e) (i) Some candidates understood that the colorimeter was being used to measure and compare the quantity of product made by the hydrolysis of ONPG at the two different concentrations of lactase enzyme. A few noted that the colorimeter could measure the increase in intensity of colour. Many understood that results would be objective and provide accurate, quantitative results. Others thought that different concentrations of enzyme were being measured over time, or that the results provided were wavelengths rather than absorbance (or transmission) readings. A common error was to describe a change in intensity of colour and a change in colour.

(ii) Some candidates were able to extract correct comparative numerical data from **Fig. 3.2** and **Fig. 3.3** to provide experimental evidence of the advantages in using immobilised lactase to produce lactose-free products. However, some gave imprecisely worded explanations, for example stating that immobilised lactase had greater activity than free lactase at the different temperatures and the different pH values. Stronger answers showed an understanding that the immobilised and free enzymes had the same activity for some temperatures and pH values and outside of these, immobilised lactase showed greater activity. Some candidates were able to explain that the immobilised lactase would allow a greater yield of product to be obtained.

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Question 4

(a) This was a question about the similarities and differences between the outer membrane of the cell wall of the Gram-negative bacterial cell and the cell surface membrane of a eukaryotic cell. Some candidates misunderstood the requirements of the question and attempted to compare the entire cell wall of the bacterial cell with the cell surface membrane of a eukaryotic cell or to compare with the cell wall of a eukaryotic cell. Common errors were to state that both had a phospholipid bilayer, rather than to acknowledge that the bacterial cell only had one layer with phospholipids and to state that the bacterial cell had peptidoglycan, which was not part of the outer membrane and should not have been considered.

(b) (i) Some candidates identified in **Fig. 4.2** that O-IMVs were composed of the outer membrane of the cell wall and the cell surface membrane and so contained cell contents. These candidates correctly based their answer on the complexity of the vesicle, or the increased time or energy required for the formation of the organelle. Some candidates wrote that the vesicle had a peptidoglycan layer, despite **Fig. 4.2** showing a section broken down so that the cell surface membrane could become part of the vesicle. Some weaker responses just described the contents of the vesicles, for example 'because OMVs have periplasmic proteins' or 'O-IMVs have plasmids' and did not qualify further.

(ii) Candidates could gain credit by suggesting a use of ATP based on the idea that there were bacterial cell contents within the O-IMV. Some correctly suggested that ATP would be in the cytoplasm of the cell that became part of the vesicle. Some candidates incorrectly suggested that the vesicle contained mitochondria, despite being formed from a prokaryotic cell lacking these organelles.

(iii) Many responses made the connection between the plasmid DNA in the O-IMV and the possibility of the presence of antibiotic resistance genes or a mutation event to produce these genes. Fewer considered the wider implication of passing on these genes to bacteria susceptible to antibiotics. Some candidates did not take into account that the O-IMV was just a vesicle and mistakenly gave a response as if the O-IMV was a living cell, for example, suggesting that vertical transmission could occur.

Question 5

(a) Good knowledge of leaf structure was shown in this question and structure **A** and tissue layer **B** were generally labelled correctly.

(b) The strongest candidates gave one example for each structural feature listed. Some candidates who had correctly stated 'cuticle' in **Question 5(a)** just wrote 'waxy', which was not a modification, instead of stating that this would be thicker. The upper epidermis was the structural feature that was most frequently incorrect as many wrote that it would be curled or infolded, which would be a modification of the whole leaf. Some candidates needed to use more precise language, and some explained the benefits of the adaptation but did not give an example.

Question 6

(a) The strongest responses were concise and effectively written. The pulmonary vein was identified as the relevant blood vessel of the pulmonary circulation at the start of their response, events occurring in the left side of the heart were sequential and included reference to blood pressure changes associated with the opening and closing of valves. These responses ended with blood leaving in the aorta, which was the relevant blood vessel of the systemic circulation.

Other answers attempted to describe a complete cardiac cycle, with some going on to describe one complete circuit of the entire body. Here, the names of all the main blood vessels associated with the heart were given. Some included details of control of the cardiac cycle. This extra information, which was not relevant to the question asked. There were some very weak answers that were extremely muddled and contained errors. There were many instances where responses should have identified which side of the heart was relevant to the question posed. There were errors in naming the valves of the heart. In particular, many wrote about a semilunar or pulmonary valve located in the pulmonary vein entering the heart.

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(b) (i) Many candidates gave a correct description of the quaternary structure of a haemoglobin molecule. The strongest answers made it clear that each polypeptide contained a haem group. Some weaker responses stated that haemoglobin was composed of four haem groups and did not mention the polypeptide chains. Some wrote generally about R-group interactions found in the tertiary structure of proteins, so incorrectly included disulfide bonds. Others did not write about structure but described the function of haemoglobin.

(ii) Many candidates were able to outline cooperative binding or state that a haemoglobin molecule could carry 4 oxygen molecules. Fewer described the precise locations in a haemoglobin molecule where oxygen binds. Some candidates gave unnecessary information detailing the role of carbon dioxide and hydrogen ions in the uptake of oxygen.

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Paper 9700/23
AS Level Structured Questions

Key messages

Candidates should read the questions carefully and give precise answers. They may benefit from reading each question multiple times and, where relevant, underlining or highlighting important words. It is especially important to respond to the command word so that the answer is relevant to the question asked, rather than writing information that may be biologically correct, but does not answer the question.

When answering questions that use the command words discuss or evaluate it may be useful for candidates to consider in their response something that supports the conclusion, something that does not support the conclusion and something to do with the validity of the experiment in their response, ideally using some data to illustrate the points made. Candidates who used this structure tended to perform well on **Question 3(b)(i)**, where they were asked to refer to data in **Fig. 3.2** to discuss whether subtilisin A is effective in preventing the attachment of the larvae of the barnacle *Amphibalanus amphitrite* to surfaces.

Some questions require the use of precise terminology. For example, in **Question 1(a)**, candidates often did not distinguish between carrier proteins and channel proteins, simply naming both as transport proteins. In **Question 3(a)**, some wrote about the substrate binding to the enzyme, rather than the more precise description of binding to the active site or using the scientific term enzyme-substrate complex.

General comments

Some candidates used appropriate scientific terminology and showing a good understanding of the syllabus learning objectives when applying knowledge to unfamiliar material, such as in **Question 1(a)**, **Question 5(a)** and **Question 5(c)**.

In **Question 5**, some candidates were confused between the antibiotics listed in **Table 5.1** and antibodies.

A common misconception in **Question 6(a)** was to write about the thickness of the ventricle wall being necessary to withstand high blood pressure. Candidates should know that the thick wall is to generate the high pressure required to overcome resistance to flow in the systemic circulation. Few candidates used the term systemic circulation, often stating that the high pressure is necessary to pump blood 'around the whole body'. Few showed an understanding that this did not include the pulmonary circulation.

In **Question 6**, many candidates found questions on tissue fluid challenging. Many wrote about tissue fluid being a means for transporting substances. Tissue fluid is the medium through which exchange of substances occurs between cells and blood. Candidates should have written about the supply of substances, such as oxygen, amino acids and glucose, and the removal of waste substances, such as carbon dioxide and urea.

Many responses to **Question 6(d)(ii)** on immunity were well written, showing good use of terminology. However, some candidates wrote a prepared answer to the events that occur in an immune response, and so did not fully address the question asked.

Some candidates had more to write than they could fit into the space available, for example in **Question 3(b)(i)**. If they write continuation answers, candidates should indicate this at the end of the answer space and clearly state which part question it is where they have continued their answer.

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Comments on specific questions

Question 1

(a) Many candidates interpreted **Fig. 1.1** correctly, and the strongest responses identified precisely 'channel protein' for row **B** and 'carrier protein' for row **C**. Most candidates gave carbon dioxide or oxygen for a substance moved by diffusion through the phospholipids in row **A** and active transport as the type of movement in row **D**. Some candidates did not notice that all four substances were depicted by different shapes, and so gave the same answer for rows **C** and **D**. Some candidates incorrectly gave calcium ions in row **C**. The most common error was to give hydrogencarbonate ions for row **D**. Stronger candidates understood that these ions travel through an exchange protein that moves chloride ions in the opposite direction in the chloride shift. The protein **D** does not show movement of two different substances in opposite directions as it would do if an antiport carrier. To give the name of the part of the membrane involved as 'transport protein' was insufficient, as all the proteins shown in the diagram can be categorised as transport proteins.

(b) Stronger candidates deduced that viruses follow the symplast pathway through plasmodesmata, from the cytoplasm of one cell to the cytoplasm of the next. Many candidates misinterpreted this question and assumed moving from cell to cell was an indication that viruses travel along the apoplast pathway in leaves. A small number of candidates mentioned that the viruses are small enough to pass through plasmodesmata.

Question 2

(a) (i) Most candidates stated that the overall structure of the molecule of collagen shown in **Fig. 2.1** is a triple helix. Far fewer noticed that each polypeptide is a helix. Some candidates incorrectly stated that the polypeptides have alpha helices and beta-pleated sheets. The coiling of the polypeptides was often given, but the reference to 'tightly' was frequently omitted. Candidates often provided information about collagen not required in the answer to this question, such as the presence of peptide bonds, the importance of glycine, or the staggered arrangement of collagen molecules in collagen fibrils. Some candidates confused collagen with phospholipids in membranes, referring to hydrophilic heads and hydrophobic tails and others confused the structure of collagen with the structures of glycogen or cellulose, referring to glucose and glycosidic bonds.

(ii) Many candidates were able to use **Fig. 2.1** to identify the parallel arrangement of the collagen molecules and their staggered arrangement. Many also stated that the molecules are held together by covalent bonds or covalent links or linkages. A few made it clear that these covalent bonds are between the R-groups on different or adjacent molecules. Some stronger candidates gave additional valid points, such as the occurrence of these covalent bonds between lysine and hydroxylysine residues. Some candidates repeated the information about the coiled nature of collagen molecules from **Question 2(a)(i)** and some gave advantages of the arrangement they had described in terms of strength and/or flexibility, which were not required.

(b) (i) Candidates were asked to suggest two properties of collagen that contribute to the function of cartilage in the trachea. Many noted the high tensile strength of collagen. This needed to be qualified with the idea of providing support. Fewer wrote about the flexibility of collagen and related this to a correct function, such as bending of the trachea or to accommodate breathing. Some candidates gave further examples about flexibility and support preventing compression of the trachea when the neck is twisted or when food moves down the oesophagus. Many stated one or two properties and needed to also explain how these properties helped the functioning of the trachea. Some candidates incorrectly stated that collagen is elastic.

(ii) Elastic fibres in the alveolar wall stretch to allow alveoli to expand without overstretching or bursting, and recoil to help expel air. Many candidates wrote answers such as 'stretch and recoil' and needed to give more specific detail.

(c) (i) Most candidates used the genetic code given in **Table 2.2** to give the correct sequence of amino acids shown in **Table 2.1**. A few gave one incorrect amino acid in the sequence and some used the template strand to identify the codons, rather than using the non-transcribed strand, even though the first amino acid was given for them in **Table 2.1**.

(ii) Many candidates stated that glycine is the smallest amino acid, with stronger responses explaining that glycine has the smallest R-group to facilitate the tight coiling of the polypeptides in each

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collagen molecule. Some candidates also stated that alanine (ala) and/or proline (pro) also have small R-groups. A few candidates mentioned that the N-H group in glycine forms hydrogen bonds and that there are many of these bonds between the polypeptides. Some candidates did not give precise enough detail, such as referring to glycine as being a small amino acid, rather than the smallest amino acid.

(iii) Stronger responses focused on the primary structure of the collagen polypeptide and correctly considered the amino acid sequence of the polypeptide. Some candidates misread the question and wrote about the sequence of bases or triplets in the DNA or described mutation **P** as a frameshift mutation. Stronger responses showed understanding that mutation **P** would result in a totally different amino acid sequence, with some correctly identifying this sequence as val-gln-trp-val-pro-glu-val-pro-gln-val, and a few pointing out that the position of some amino acids in the sequence does not change. Many candidates wrote that the first amino acid changes from gly to cys for mutation **Q** but also needed to state that the rest of the sequence of amino acids remains unchanged. A common error was to state that the first amino acid becomes phe not cys, presumably by reading TTC instead of TGT.

Question 3

(a) Many candidates gave confident answers describing the induced-fit model of enzyme action. Many stated that before a reaction begins, the active site of an enzyme does not have a complementary shape to the substrate and that the shape of the active site changes as the substrate enters or binds to the active site to give a complementary shape or a perfect fit between active site and substrate. Most also mentioned that the enzyme-substrate complex can then form. Fewer candidates went on to state that the activation energy is lowered and that when the products leave, the enzyme the active site returns to its original shape. It was not sufficient to state that the product leaves the active site. Some candidates incorrectly referred to the shape of the substrate changing to fit the active site. Weaker responses omitted any reference to active sites, or did not state that the induced-fit method requires a change in shape of the active site, or wrote about the substrate leaving the enzyme after the enzyme-substrate complex forms.

(b) (i) This question required candidates to analyse the data in the bar chart in **Fig. 3.2** and discuss the effectiveness of immobilised subtilisin A on preventing attachment of barnacle larvae to surfaces. The strongest responses concisely covered a wide range of ideas based on the results shown. Many candidates stated that the enzyme was effective because the percentage attachments in the tanks with active enzyme were so much less than in the tanks with denatured enzyme and with glass slides. Some went on to support this statement with data. A few candidates, whilst giving data comparing tanks 1 to 4 with a control tank, either never stated that subtilisin A was effective in preventing attachment or stated that it was not effective. Some considered other interpretations, for example stating that apart from tank 2, the percentage attachment increased between 24 and 48 hours, showing that the enzyme was not particularly effective. A few stated that over longer periods of time, it was possible that the enzyme would become even less effective. Some candidates correctly noted that there was no trend in effectiveness as the concentration of enzyme increased. Few candidates evaluated the experiment, for example by stating that this investigation had only been carried out once or that there were no repeat results.

(ii) Candidates suggested a wide range of factors that need to be considered if the investigation were to be extended to finding out if immobilised subtilisin A is suitable as an anti-fouling agent for ships. Common answers were the concentration of subtilisin A; the concentration of sea water, which varies across the seas and oceans; the presence of fouling organisms other than *Amphibalanus amphitrite*; the possible effect of the polymer or enzyme on the marine ecosystem; the length of time that it would carry on working; the length of time the enzyme remained active and the effect of something in the water that may act as an enzyme inhibitor. Some candidates referred to temperature and pH and/or the concentration of the substrate without identifying the substrate.

Question 4

(a) (i) Few candidates stated clearly that monomers are repeating sub-units that combine to make a polymer. Most stated that they were either repeating units or that it was a unit that formed a polymer or strand of DNA, but not both. There were many incorrect answers including ‘a unit of DNA’, ‘a molecule that joins with others to make DNA’ and ‘building blocks of DNA’. None of these conveyed the idea of units that are repeated. Some candidates described the structure of a

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nucleotide. Some weaker responses gave descriptions such as 'bases that are similar that form a chain.'

(ii) Only the strongest candidates were able to state how ATP differed in structure from the phosphorylated nucleotide shown, most commonly stating that ATP has ribose rather than the deoxyribose in the phosphorylated nucleotide. Candidates often referred to the nature of the base rather than the pentose sugar. Some noted that ATP did not have deoxyribose, but needed to also add that it had ribose. Many candidates referred to ATP having 3 phosphate groups as a difference, even though the nucleotide in **Fig. 4.1** also had 3 phosphate groups.

(iii) Most candidates gave respiration as the process that results in the production of ATP. Many qualified their answer with aerobic and less often with anaerobic. Translation, protein synthesis, cell signalling and active transport were common incorrect answers. Candidates who gave these answers may have misread the question, thinking they had to give uses of ATP.

(b) (i) Stronger responses to this question showed two hydrogen bonds drawn correctly between the top pair of bases, which some candidates identified as thymine and adenine, and the three hydrogen bonds between the lower pair of bases – cytosine and guanine. These identifications were not necessary, but did confirm correct knowledge. Many candidates drew dashed lines to represent hydrogen bonds between T and A and between C and G but not in the correct positions. Some candidates drew lines between the two bases on the same strand, usually T and C.

(ii) Most candidates gave phosphodiester bond as the type of bond indicated by **X** on **Fig. 4.2**. Common incorrect answers included ester bond, peptide bond, polypeptide bond, phosphate bond, polydiester bond and phosphorus bond.

Question 5

(a) Many candidates realised that erythromycin binds only to the 70S ribosomes found in prokaryotes. These candidates often stated that humans have 80S ribosomes while bacteria, such as *Vibrio cholerae*, only have 70S ribosomes. A few candidates stated clearly that the target site or binding site for erythromycin is not present on 80S ribosomes or is only present on 70S ribosomes. Some referred to active sites of erythromycin rather than the target or binding sites on the 70S ribosomes. Some candidates did not mention ribosomes; instead writing vaguely about the role of antibiotics. Very few mentioned the fact that mitochondria in human cells have 70S ribosomes and that erythromycin does not reach them or that the 70S ribosomes in mitochondria differ from the 70S ribosomes in prokaryotes in such a way that erythromycin does not bind to them.

(b) Penicillin prevents the formation of cross links between peptidoglycans in bacterial cell walls. Many candidates stated that penicillin acts on cell walls but did not add that human cells have no cell walls to explain why penicillin has no effect on human cells. A few candidates gave detailed answers explaining that gaps are made by autolysins in bacterial cell walls during growth and it is the repair of these gaps that is the target for penicillin.

(c) Many candidates give a clear explanation of how rifampicin may inhibit the action of RNA polymerase. These candidates described competitive inhibition or non-competitive inhibition. Some strong responses displayed knowledge of the term allosteric site. Candidates needed to include some description of the mode of action in their response, simply stating the terms competitive inhibition or non-competitive inhibition was insufficient. Some candidates needed to be more precise and include the active site in their description. Other suggestions that were seen included binding to the promoter region to inhibit RNA polymerase starting transcription, binding to the DNA template to stop the movement of RNA polymerase, or the incorporation of rifampicin into the new strand of RNA, so blocking the addition of the next nucleotide by the enzyme.

Question 6

(a) The features that most candidates identified from the photograph of the dissection of the left side of the heart were the bicuspid or left atrioventricular valve and the thickness of the left ventricular wall. Features identified less frequently were the semi-lunar or aortic valve, the tendinous chords or tendons attached to the atrioventricular valve and the papillary muscles. Some candidates simply wrote 'valve' or 'valves' as a feature and needed to also state that the valve prevents backflow of blood or make sure that blood flows in one direction. Some candidates gave only one feature and left part of the answer space blank. Others named a main blood vessel associated with the heart

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rather than a feature of the left side of the heart. Some candidates missed the reference to the left side of the heart and wrote about the right ventricle and the tricuspid valve, while others simply referred to the left side of the heart having thicker walls without mentioning the ventricle. Many candidates incorrectly thought that the reason for having a thicker ventricular wall was to withstand pressure, rather than generate a high pressure or a high force.

(b) Some candidates gave very well-expressed descriptions of how electrical activity within the heart controls each heartbeat. Many described the roles of the sinoatrial node (SAN) and the atrioventricular node (AVN) with appropriate detail. The delay of the impulses at the AVN and its role in relaying impulses to the Purkyne fibres were often stated correctly. Common omissions included the fact that Purkyne fibres conduct impulses to the base or apex of the heart to stimulate contraction of the ventricular walls. Some candidates only used the abbreviations associated with the two nodes and needed to give the full names in their response.

(c) (i) Only the strongest candidates gave two correct functions of tissue fluid. Some candidates described the exchange of oxygen and carbon dioxide between cells and blood. A small proportion mentioned the removal of metabolic waste, such as urea, and described the ability of phagocytes to move within tissue fluid. A few also stated that tissue fluid flows into lymphatic vessels to form lymph. A common error was to refer simply to 'nutrients' rather than to specific nutrients that are supplied through tissue fluid, such as glucose, amino acids and ions. Many candidates described the role as being involved in the transport of nutrients and respiratory gases, which is a function of blood and not tissue fluid.

(ii) Many candidates gave good descriptions of the formation of tissue fluid. Many stated that there is a high hydrostatic pressure at the arteriolar end of the capillary network so that fluid or some components of plasma can leave capillaries through endothelial pores. Some correctly described this movement as ultrafiltration or pressure filtration. Weaker responses described the exit of the components as diffusion or osmosis.

(d) (i) Many candidates needed to provide more detail in their responses to this question. Candidates often knew that recognition of the measles vaccine only occurred with specific T-lymphocytes, which are then activated, but only some of these stated that this is because they have receptors complementary to the antigen in the vaccine.

(ii) Many candidates were able to describe the events that occur during an immune response that lead to long-term immunity. Many stated that long-term immunity is a result of the formation of memory cells and included the selection of appropriate lymphocytes and the expansion of small clones of these cells in their responses. Some candidates stated that memory cells provide long-term immunity, restating the phrase from the question, and needed instead to mention that memory cells persist in the blood or the circulatory system or lymph nodes for a long time. Some candidates needed to take care to address the specific question asked in their response.

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Paper 9700/24
AS Level Structured Questions

Key messages

Where a space is provided to do so, such as in **Question 1(a)(ii),** candidates may benefit from drawing a diagram to help their answer. There were some excellent diagrams drawn that were labelled and/or annotated so that the information shown could be used as part of a correct response.

Candidates should use the correct scientific terminology, with the terms spelled correctly. For example, in **Question 1(a)**, some candidates were not able to name or spell correctly the nuclear envelope, the nuclear pore or the nucleolus. In **Question 4(a)**, the bronchus, and in **Question 4(b)(i)**, the alveolus, were the answers required. Many incorrect spellings of these terms were seen, particularly of the alveolus.

When describing the structure of a vein or artery, candidates may benefit from organising their response by including reference to the three main layers of the wall of the blood vessel, the tunica intima (tunica interna), the tunica media and the tunica externa (tunica adventitia). With the vein, the presence of valves should also be mentioned. Some of the stronger answers in **Question 5(b)**, which asked how the structure of a vein is related to its function, were organised in a similar way to produce clear and concise answers. Although in this question, details of the tunica intima were not required.

General comments

Some candidates displayed good knowledge of the syllabus. Many of these candidates were able to give strong responses to question items that contained unfamiliar material, such as those in **Question 2** and **Question 3**.

Most candidates attempted to answer all items. There were some questions where candidates had some relevant ideas but needed to give extra detail or further qualification in their response.

A number of candidates could have benefited from taking more time to read questions and to check their answers. Candidates should be encouraged to read questions carefully. In **Question 2(d)(i)**, some candidates described the events occurring in a phagocytic cell after a response has been caused, rather than how the presence of phospholipid phosphatidylserine (PS) can cause a response in a phagocytic cell. In **Question 2(e)(i)**, some mistakenly thought the question was about the ability of *Plasmodium* to infect the cell, despite the introduction of **Question 2(e)** stating that it uses cholesterol from the red blood cell it has infected. In **Question 5(a)(i)** some candidates named the cell structures that organise the formation of spindle fibres in mitosis, suggesting they had misread the question which asked for the name of the cell structures that are organised to form spindle fibres in mitosis.

Comments on specific questions

Question 1

(a)(i) Many candidates correctly explained the difference in chromatin as being due to the S phase, or DNA replication that occurred in the time interval between the G1 and G2 phases of interphase. Some incorrectly suggested that DNA replication occurred in G2. It was too vague to state that chromatin replicated in the S phase as this would include the histone proteins, which are also produced in the G1 phase. The most common difference stated was the doubling in DNA quantity. Some of those who wrote about the presence of two sister chromatids joined by a centromere made the error of stating ‘chromatins’ instead of chromatids.

(ii) Stronger responses included all the expected detail of the structure of a nucleus and used the correct terms, spelled correctly. The double membrane of the nuclear envelope was frequently described, with fewer noting the presence and role of nuclear pores. Some candidates made a

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correct reference to the exit of messenger RNA (mRNA) or the entry of proteins through the nuclear pores. Others incorrectly gave examples of substances, such as sucrose. Although some candidates recalled that the nucleus contained a nucleolus, fewer gave further detail about the shape, appearance or role of the structure. Some candidates used the space provided to draw a diagram and although some were of poor quality, others were drawn and labelled well and described one or more features of a nucleus.

(b) (i) Most candidates showed a good understanding of the two polysaccharides, starch and cellulose. Most were able to give a clear, comparative account to highlight the structural features of starch that are different from those of cellulose and many gave specific information about the two polymers of starch, amylose and amylopectin.

(ii) For this question, candidates needed to visualise that a particular RG-I pectin had a number of different-shaped regions owing to the location and type of side chains that are present. This understanding was shown by some candidates. Others suggested that each particular RG-I required only one type of monoclonal antibody to bind to it. Candidates also needed to understand that different antigens have different shapes that are each complementary to a particular monoclonal antibody, which explains why scientists can use a range of different monoclonal antibodies to investigate a particular RG-I. Many knew that monoclonal antibodies were specific in their action, with the strongest responses correctly describing antigen binding sites and showing an understanding that each of the different shapes within RG-I was acting as an antigen.

A few strong candidates explained how different monoclonal antibodies could be used as changes occurred in the cell wall during development and some suggested that different fluorescent antibodies could be used to locate and identify different types of RG-I pectins.

Question 2

(a) Many candidates were able to correctly identify whether the diseases listed were caused by a prokaryotic or eukaryotic organism. Weaker candidates often knew that cholera was caused by a prokaryotic organism, but frequently stated incorrectly that malaria was caused by a prokaryotic organism and occasionally that TB was caused by a eukaryotic organism.

(b) The majority of candidates answered this question correctly. Incorrect responses included bacteria, virus and parasite. Some candidates did not understand the question and gave a mode of transmission of disease.

(c)(i) Most candidates were able to correctly calculate the magnification of the image in **Fig. 2.1**. A few candidates measured length **X–Y** in cm and needed to convert to mm before multiplying by 1000, and some who had measured a length that was too long or too short to be considered acceptable.

(ii) Most candidates knew that *Anopheles* or a mosquito was involved in the transmission of *Plasmodium* and many stated this was the vector. The descriptions of how the vector obtained the blood of the infected person, and/or how the vector introduced the pathogen into the blood of the uninfected person, varied greatly. The strongest responses used terms such as ‘takes a blood meal’, ‘feeds on blood’ and ‘sucks blood’, which were appropriate and made it clear that the pathogen was in the blood removed. Some used the term ‘bites’ and needed then to continue to include the idea that blood had been taken. Some described how plasmodium enters the blood stream with the anticoagulant produced in the mosquito salivary gland.

(d)(i) Many candidates understood that a response in a phagocytic cell can be stimulated by the presence of a non-self, or foreign, antigen, and that PS could be acting as an antigen. Stronger candidates wrote about the presence of a receptor on the cell surface membrane of the phagocyte that binds PS. Some suggested that the presence of PS allowed chemotaxis to occur.

(ii) The standard of response varied greatly in this question. Some candidates had deduced from the information provided at the start of **Question 2(d)** that there was a chance of a few uninfected red blood cells being recognised by a phagocyte as they still had a small quantity of PS in the outer layer of the cell surface membrane. Some recalled that a red blood cell had a short life span and suggested it might have been recognised as an old cell that needed to be removed from the circulation. Weaker responses gave less plausible suggestions, such as the phagocyte making a mistake, or the red blood cell becoming mutated and appearing to be infected, or the need to destroy red blood cells to stop them becoming infected.

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(e)(i) Candidates needed to understand that the cholesterol from the cell surface membrane of the red blood cell was used by *Plasmodium* as part of the infective stage within the cell. Most suggested that cholesterol was important for the fluidity and/or stability of the cell surface membrane of the pathogen. A few suggested that cholesterol could be used for energy. Very few suggested that the cholesterol could be used by *Plasmodium* for the production of its own membranes during replication within the host red blood cell. Some candidates may have misread the introduction to **Question 2(e)** as they made suggestions relating to the ease of entry by *Plasmodium* into the red blood cell.

(ii) Some candidates understood that if the red blood cell lost cholesterol from the cell surface membrane the stability would be decreased because of an increase in fluidity. Many candidates incorrectly associated a decrease in cholesterol in the cell surface membrane of a red blood cell with a decrease in fluidity. Others described how changes in temperature would have an effect on the cell surface membrane, which was not relevant to the question.

(f)(i) Many candidates understood that movement of the phospholipids would be against the concentration gradient and would be an active process and hence require energy provided by ATP. Many incorrectly used the term active transport to describe this. Stronger candidates were aware that whole molecules were being moved from one layer to the other by the two enzymes flippase and floppase, rather than being transported across the entire membrane, making this term incorrect.

(ii) The most common correct suggestion was that the cell could use active transport to move Ca^{2+} out of the cell. Others gave valid suggestions related to the lack of transport proteins to allow the entry of Ca^{2+} or the impermeability of the cell surface membrane to Ca^{2+}. Some candidates stated that active transport could occur but needed to include the direction of movement of the Ca^{2+} in their response. Some gave vague answers stating that the cell prevented the entry of the ion and needed to give more specific detail.

(iii) Many candidates referred to **Table 2.1** to deduce that scramblase would be activated with an increase in Ca^{2+}. The strongest candidates gave a consequence of the activation of scramblase by providing details of how the arrangement of specific phospholipids would change so that the normal situation of asymmetry would be disrupted. Weaker candidates repeated the information from the question that the asymmetry would be disrupted but needed to explain how this disruption would occur.

Question 3

(a)(i) **Step 1** of **Fig. 3.1** showed a primary transcript with a loop. In **step 2**, a double stranded section of RNA was shown. Many candidates applied knowledge of complementary base pairing to suggest this as the way to maintain the double stranded section, and generally those who gave more detail, also stated uracil, instead of thymine, pairing with adenine. Some noted hydrogen bonds would be formed. Candidates who also named both phosphodiester bonds needed to make clear that hydrogen bonds were between complementary bases or complementary nucleotides and that phosphodiester bonds joined adjacent nucleotides. Weaker responses wrote only about the loop forming and needed to add the detail about pairing between the bases.

(ii) Candidates needed to apply their syllabus knowledge about the specificity of enzymes to answer this question. Weaker candidates needed to include detail involving the active site, such as the active site being the correct shape to allow binding of the substrate, or how the specific active site allowed the formation of an enzyme-substrate complex for cleavage. There were some strong responses, some of which also suggested that the functioning of the different enzymes was suited to the two different cell locations.

(b) Candidates used **Fig. 3.1** to refer to siRNA and compare this molecule to their knowledge of mRNA. Most knew that mRNA was single stranded to compare this with the double-stranded portion of siRNA. The most common error was to state that mRNA had paired nucleotides or did not have unpaired nucleotides.

(c)(i) Candidates needed to use **Fig. 3.2** to deduce why the passenger strand is separated from siRNA when the complex known as RISC forms. Many realised that the guide strand would not be free to base pair with the mRNA to be cleaved if it was still joined to the passenger strand. Others stated

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that RISC would not be able to target the correct location for cleavage. Weaker candidates just stated that the passenger strand is not needed, and some thought the passenger strand needed to be free to be able to bind to the mRNA, despite **Fig. 3.1** showing the guide strand binding.

(ii) In this question, candidates needed to use knowledge of translation to suggest how cleaving mRNA in different locations could affect protein synthesis and hence result in a lack of functioning protein. Quite a few suggested that cleavage before the stop codon would result in a shortened polypeptide. Some candidates considered the wrong stage of protein synthesis and wrote about mutations and the effect of frameshift mutations. If a cleaved mRNA is still able to attach to the ribosome, it would be a shorter molecule yet the sequence of amino acids would still be the same. Stronger candidates were able to consider cleavage occurring at different key points to suggest other effects. For example, cleavage in which the start codon would be lost could result in mRNA not being able to attach to the ribosome, so that translation would not occur. To answer the question fully, stronger responses also explained how changes to the polypeptide chain could alter the ability to form the correct R-group interactions in the polypeptide. Very few considered the ability of cells to break down abnormally-formed molecules.

Question 4

(a) Most candidates knew that the bronchus was the airway that branched into bronchioles.

(b)(i) Many candidates knew the alveolus is a structure where gas exchange is carried out. However, there were many different incorrect spellings of alveolus seen. Common incorrect answers were smooth muscle and capillaries.

(ii) Fewer candidates knew the correct answer for this question than in **Question 4(a)** and **(b)(i)**. Incorrect answers included endothelial cell, epithelial cell, goblet cell and squamous cell, despite the label lines in **Fig. 4.1** showing cells that were not lining cells.

(iii) Many candidates knew that bronchioles do not possess cartilage. Cartilage was not always spelled correctly, with ‘cartlidge’ being a common error. Many also cited a lack of goblet cells, with fewer noting a proportionately lower quantity of smooth muscle and elastic fibres, or a thin wall. Some responses only gave one feature, and needed to give detail of further features.

(c) Many candidates described the lungs as the location of gas exchange. The strongest responses clearly described the difference between the blood supplied by the pulmonary circulation and the blood supplied by the systemic circulation. These explained the role of the pulmonary circulation in gas exchange to obtain oxygen and pass out carbon dioxide, and the role of the systemic circulation in delivering oxygen and glucose to the cells of the lungs. Others gave a more disorganised account. It was important to identify which circulation was being referred to.

Question 5

(a)(i) Many candidates knew that microtubules are the cell structures that are organised to form spindle fibres and many of these gave the correct spelling of the term. The most common incorrect spellings were ‘microtubles’ and ‘microtubuals’. Some candidates named centrioles or the centrosome as the cell structures that organise the formation of the spindle suggesting they may have misread the question.

(ii) Good knowledge of the telophase stage of mitosis was shown by many candidates, and some gave comprehensives descriptions covering all the main features. The disassembling of the spindle and the reassembling of the nuclear envelope were frequently described. Stronger responses made it clear that the sister chromatids that were separated at anaphase, which could now be termed daughter chromosomes, had reached their opposite poles, and that the nuclear envelopes were re-assembling around each group of chromosomes. Some incorrect concepts of telophase included describing the chromosomes as moving towards the poles, describing the nuclear envelope as a nuclear membrane, and stating that the chromosomes were condensing rather than de-condensing, or that chromosomes were disappearing.

(b) This question asked candidates to relate the structure of a vein to its function. Reference to valves was seen most frequently, and most correctly related this to preventing the backflow of blood or to facilitating the flow of blood back to the heart. A common error was to describe the valve as semilunar. Stronger candidates showed knowledge of the location of collagen in the tunica externa

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and smooth muscle and elastic fibres in the tunica media. These candidates correctly related the function of smooth muscle and elastic fibres to the role of a vein in returning blood that has a very low pressure back to the heart. The function of collagen in the tunica externa to prevent collapse and to support the vein was noted by some candidates. Some candidates erroneously wrote about smooth muscle, elastic fibres and collagen in terms of functioning to withstand the high pressure of blood. Some wrote about the tunica intima even though they had been instructed not to do so.

Question 6

(a) The strongest responses clearly identified the immature or growing leaf as a sink and the mature leaf as a source and gave one or more features of each. Others described features of a source and a sink and needed to make a link to the immature or mature leaf. Some candidates did not address the question asked and gave a general description of leaves as sources and roots as sinks.

(b) Most candidates knew that the guard cell is one of a pair that form a stoma and deduced that the epidermal cell secretes a waxy substance. The palisade mesophyll cell was generally chosen as the photosynthetic cell; those who gave spongy mesophyll cell were not correct as these are not columnar-shaped. Many candidates correctly linked statement **C** to a phloem sieve tube element, with reference to receiving water to build up hydrostatic pressure for mass flow. A few candidates incorrectly chose the xylem vessel element.

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Paper 9700/31
Advanced Practical Skills 1

Key messages

Candidates should be given the opportunity to experience a variety of practical work throughout the course, to develop the skills that can be applied to the requirements of the exam.

Candidates should be aware that within an investigation, they should be able to draw a graph clearly and accurately with the independent variable on the x-axis and the dependent variable on the y-axis. Each axis should be labelled to match the relevant table headings, including units where appropriate and using a scale where both axes should use most or all of the grid available. If there is more than one line on the graph, each should be identified either on the graph or by means of a key. All the graph points should be plotted accurately using a sharp pencil, as a small cross or a small dot in a circle. The plotted points of the graph should be connected with a clear, sharp and unbroken line, either as a line of best fit or a smooth curve or with ruled straight lines joining the points.

General comments

In general, many candidates demonstrated that they had a good understanding of the skills required. There was good discrimination between the weaker and more able candidates and the majority of candidates showed that they were familiar with the use of the microscope.

Comments on specific questions

Question 1

(a) (i) Many candidates were able to carry out a serial dilution of the 2.0% hydrogen peroxide solution, showing the correct concentration below each beaker (1.0, 0.5, 0.25 and 0.125%) and the transfer of 10 cm^3 from the previous concentration to the next beaker and the addition of 10 cm^3 of distilled water to each beaker.

(ii) Many candidates organised their results clearly by presenting a ruled table. The stronger responses included the heading for percentage concentration of hydrogen peroxide to the left of the data and included the heading for the dependent variable as time with appropriate units, seconds. Most candidates correctly recorded a time for each concentration and recorded the results as whole seconds.

(iii) The majority of candidates correctly recorded the time taken for the blue-black colour to appear for **U1**, **U2** and **U3**, recording the times in seconds.

(iv) Many candidates correctly calculated the mean time taken for the blue-black colour to appear by showing the addition of the three times and division by three.

(v) Many candidates used their results in **Question 1(a)(ii)** and **Question 1(a)(iv)** to correctly estimate the concentration of hydrogen peroxide in sample **U** and gave the correct unit, %.

(vi) Some candidates correctly explained that repeating the measurement for sample **U** allowed any anomalies to be identified and discarded.

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(vii) Some candidates correctly stated that using smaller intervals between concentrations of hydrogen peroxide around the estimate would be a modification to the procedure that would allow a more accurate estimate of the concentration of hydrogen peroxide in sample **U**.

(b) (i) Most candidates correctly used the headings given in **Table 1.2** to correctly label the x-axis (time / hours) and the y-axis (percentage of bacterial cells able to produce hydrogen peroxide). The stronger responses labelled the lines on the graph to identify which line was bacterial cells at 20 °C and which line was bacterial cells at 37 °C. Some candidates labelled the incorrect axis or gave incomplete headings. The stronger answers used a scale of 40 to 2 cm for the x-axis, and a scale of 4 to 2 cm for the y-axis. Many candidates plotted all the points accurately and joined the points with a thin line. The most common error was not using the correct scale for the y-axis.

(ii) Many candidates gave two correct conclusions from the results of the investigation at the two temperatures by stating that for both temperatures the percentage of bacterial cells able to produce hydrogen peroxide increased as time progressed and that there was a greater increase in the percentage of bacterial cells at lower temperatures.

(iii) Some candidates correctly drew a line on their graph, at 14.5% to show how they obtained an estimate of when the sample was taken.

(iv) Some candidates correctly stated a variable that the scientists needed to keep constant so that the results at the two temperatures could be compared by using the same species of bacteria, using the same pH or providing identical addition of nutrients.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the whole section on **J1**. Many candidates gained credit for drawing the correct shape of the vascular tissue and for drawing details of the tissue within the extensions of the stem. Many candidates used a label line and a label to correctly identify the xylem.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin lines which joined up precisely and used most of the space provided. Many candidates were able to draw four adjacent epidermal cells with each cell touching at least one of the other cells, with double lines representing the walls. The most common error was to draw lines that did not meet up precisely or were too thick. Many candidates were credited for drawing the correct shape and proportion of these cells. Many candidates used a label line and a label to correctly identify the waxy cuticle.

(iii) Many candidates correctly identified observable differences between the stem section on **J1** and the stem section in **Fig. 2.1**. Observable differences that were correctly identified included the presence of a thick cuticle on **J1** and the absence of a cuticle in **Fig. 2.1**, the cortex cells on **J1** were smaller than in **Fig. 2.1** and there were no trichomes on **J1** but trichomes were present in **Fig. 2.1**.

(b) (i) Many candidates correctly stated the number of whole vascular bundles in sector **P**.

(ii) To estimate the number of vascular bundles in the stem section some candidates correctly showed the division of 360 by 15 and then multiplied by their answer from **Question 2(b)(i)**.

(iii) To calculate the density of vascular bundles in the stem section some candidates correctly divided their answer from **Question 2(b)(ii)** by 44 and gave their answer to two significant figures.

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Paper 9700/33
Advanced Practical Skills 1

Key messages

Candidates should be given the opportunity to experience a variety of practical work throughout the course, to develop the skills that can be applied to the requirements of the exam.

Candidates should be aware that within an investigation, they should be able to draw a graph clearly and accurately with the independent variable on the x-axis and the dependent variable on the y-axis. Each axis should be labelled to match the relevant table headings, including units where appropriate and using a scale where both axes should use most or all of the grid available. If there is more than one line on the graph each should be identified, either on the graph or by means of a key. All the graph points should be plotted accurately using a sharp pencil, as a small cross or a small dot in a circle. The plotted points on the graph should be connected with a clear, sharp and unbroken line, either as a line of best fit or a smooth curve or with ruled straight lines joining the points.

General comments

In general, many candidates demonstrated that they had a good understanding of the skills required. There was good discrimination between the weaker and more able candidates and the majority of candidates showed that they were familiar with the use of the microscope.

Comments on specific questions

Question 1

(a) (i) Most candidates correctly stated that the volume of distilled water to use in order to make 20 cm^3 of a 1.0% glucose solution was 19 cm^3.

(ii) Many candidates were able to show how to carry out a serial dilution of 1.0% glucose solution by transferring 10 cm^3 of the previous concentration to the next beaker and adding 10 cm^3 of distilled water to each beaker.

(iii) Many candidates correctly stated that the volume of Benedict's solution to use was at least 2 cm^3 as equal or excess volume was required to carry out the Benedict's test.

(iv) The majority of candidates correctly completed **Table 1.3** by stating a time for each concentration of glucose showing that the time taken to the first colour change for 1.0% glucose was less than the time taken for 0.0625% glucose.

(v) Many candidates organised their results clearly by presenting a ruled table. The stronger candidates included a heading for time of sampling and minutes to the left of the data and included the heading for the dependent variable as time to first colour change and the appropriate units, seconds. Most candidates gained credit for recording a time for each of the sampling times of 5, 10 and 15 minutes. Most candidates correctly recorded their results as whole seconds.

(vi) Many candidates correctly stated that the source of error when carrying out the Benedict's test was identifying accurately the time of the first appearance of colour.

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(vii) Many candidates correctly used their results in **Question 1(a)(iv)** and **Question 1(a)(v)** to estimate the percentage concentration of glucose in the sample taken at 5, 10 and 15 minutes. The stronger candidates stated that the estimate was between known percentage concentrations of glucose.

(viii) Some candidates correctly suggested that the reason for the percentage concentration of glucose estimated in **Question 1(a)(vii)** was that the longer the dialysis tubing was left the more glucose diffused out of the tubing into the water.

(b) (i) Most candidates correctly used the headings given in **Table 1.4** to correctly label the x-axis (time sample was taken from the blood / min) and the y-axis (concentration in the blood, of **P** and **Q** / arbitrary units). Some candidates labelled the incorrect axis or gave incomplete headings. The stronger responses used a scale of 5 to 2 cm for the x-axis and used a scale of 50 to 2 cm for the y-axis. Many candidates plotted all the points accurately and joined the points with a thin line. The most common errors were not using the correct scale for the y-axis and not identifying which line on the graph was the concentration of **P** and which line was the concentration of **Q**.

(ii) Many candidates correctly calculated the percentage decrease in concentration of **Q** between 5 minutes and 20 minutes by showing 280 minus 75, divided by 280 and multiplied by 100 and giving the answer to two significant figures.

(iii) Some candidates correctly stated that the reason for the rate of decrease in the concentration of **Q** from 0 to 10 minutes was that there was a steep concentration gradient between the blood and the dialysate and a rapid diffusion of **Q** out of the blood into the dialysate. The strongest responses also correctly stated that from 10 to 20 minutes the concentration gradient was less steep.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the region of the root on **K1** indicated by the shaded area in **Fig. 2.1**. Many candidates gained credit for drawing at least four layers of tissue and the correct proportion of the vascular tissue relative to the diameter of the root. Many candidates used a ruled label line and the label **T** to correctly identify the tissue involved in the transport of substances throughout the plant (xylem or phloem).

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin lines which joined up precisely and used most of the space provided. Many candidates were able to draw four adjacent cells from the centre of the root on **K1**, with each cell touching at least one of the other cells, with double lines representing the walls. The most common error was to draw lines that did not meet up precisely or were too thick. Many candidates were credited for showing cells which had at least five sides.

(b) Many candidates drew label lines on **Fig. 2.2** to show the three differences they had identified. Included in the observable differences that were correctly identified were that there were more layers of tissue present in **Fig. 2.2** than on **K1,** there were more xylem vessels in **Fig. 2.2** than on **K1** and there were no trichomes in **Fig. 2.2**, but trichomes were present on **K1**.

(c) (i) Many candidates correctly stated that the diameter of the root, line **A** – **B,** was 77 mm. The strongest responses then showed the diameter of the root divided by 35 and divided the answer by 2 to find the value for the radius. Many candidates then used this value for the radius to calculate the actual area of the vascular tissue and gave their answer in mm^2.

(ii) Some candidates correctly suggested modifications to the method used in **Question 2(c)** to investigate the hypothesis that the area of vascular tissue in a root section changes as the plant grows. These suggestions included growing plants of different ages of the same species under the same growing conditions such as temperature of the environment, the same light conditions and providing the same amount of water to each plant. The strongest responses then went on to suggest measuring the area of vascular tissue in the roots of plants of different ages.

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Paper 9700/34
Advanced Practical Skills 2

Key messages

Candidates should be given the opportunity to experience a variety of practical work throughout the course, to develop the skills that can be applied to the requirements of the exam.

Candidates would benefit from practice in accurately describing an experimental procedure before carrying it out. Candidates should follow instructions to carry out investigations carefully and record all of their results in an appropriate table, for example, a colour for each of the tests for **S1**, **S2**, **S3** and **S4**.

Candidates should be aware that within an investigation, they should be able to draw a graph clearly and accurately with the independent variable on the x-axis and the dependent variable on the y-axis. Each axis should be labelled to match the relevant table headings, including units where appropriate and using a scale where both axes should use most or all of the grid available. If there is more than one line on the graph, each should be identified either on the graph or by means of a key. All of the graph points should be plotted accurately using a sharp pencil, as a small cross or a small dot in a circle. The plotted points of the graph should be connected with a clear, sharp and unbroken line, either as a smooth curve or with ruled straight lines joining the points.

Candidates would benefit from practice reading values from a graph to the nearest value of half a small square rather than to the nearest solid line.

Where the question stated, 'Suggest an explanation for the trend in the data when the plant was in the dark and when the plant was in the light', the candidates needed to make sure to give reasons as to why the concentration of reducing sugars decreases in the dark and increases in the light in both the leaves and the phloem sieve tubes, using their knowledge about plant transport.

Candidates should be encouraged to observe fine detail when viewing slides under a microscope or on a photomicrograph. They should include such detail when producing diagrams, for example, the shape of cells in high power diagrams, and the pattern of vascular bundles and presence of trichomes in a plan diagram.

General comments

In general, many candidates demonstrated that they had a good understanding of the skills required. There was good discrimination between the weaker and more able candidates. The majority of candidates showed that they were familiar with the use of the microscope.

Comments on specific questions

Question 1

(a) (i) The majority of candidates were able to correctly state Benedict's as the reagent to use to test for reducing sugars and a colour that is produced if reducing sugars are present. Many candidates described using a boiling water-bath or stated a temperature of at least 80 °C.

(ii) Most candidates correctly stated Benedict's, dilute hydrochloric acid (**A**) and sodium hydrogen carbonate powder (**H**) as the reagents to use to test for non-reducing sugars, and stated a colour that is produced if non-reducing sugars are present. Many candidates described adding the acid and heating it to hydrolyse the non-reducing sugars and then adding sodium hydrogen carbonate

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powder to neutralise the solution before carrying out the Benedict's test. A few candidates incorrectly stated iodine as the reagent to use and described the test for starch.

(iii) Many candidates organised their results clearly by presenting a ruled table and included the heading solution and the heading colour for each test carried out: reducing sugars, non-reducing sugars and starch. Candidates gained credit for recording the correct colours for each test carried out on the four solutions (**S1**, **S2**, **S3**, **S4**).

Some candidates only recorded the colours for two tests, most commonly not recording the test for reducing sugars or for starch, or they incorrectly recorded the biological molecules present in each solution. Some candidates needed to record colours for the negative tests.

(iv) The majority of candidates who had recorded colours for all three tests in **Question 1(a)(iii)**, were able to use their results to correctly suggest which solution represented each of the plant extracts in **Table 1.2**.

(v) The majority of candidates correctly described how to identify which of the solutions could contain protein. They gained credit for describing the use of potassium hydroxide and copper sulfate or for stating the use of biuret solution. Credit was also awarded for stating that a purple colour indicated that protein was present. A few candidates incorrectly described the emulsion test for lipids, and a few candidates described the test for starch using iodine.

(b) (i) Most candidates drew the graph, using the headings given in the table to correctly label time / hours on the x-axis and concentration of sugars / μmol on the y-axis and used a key to identify the line for leaves and the line for phloem sieve tubes or labelled each line. Many of the candidates used scales of 5 hours to 2 cm for the x-axis and 0.10 μmol to 2 cm for the y-axis and plotted the points for both leaves and phloem sieve tubes exactly with a dot in a circle or a small cross. Some candidates did not gain credit as they used the sample times labelled at each 2 cm for the x-axis, giving a non-linear scale, which meant that the points could not be plotted accurately. Many candidates drew a sharp, clear ruled line or a curve accurately connecting the points for each line.

The most common errors were using a scale of sample times on the x-axis and drawing dotted lines plot to plot that did not accurately connect the points. A few candidates incorrectly calculated the mean concentration of sugars at each sample time and drew a graph with one line.

(ii) Most candidates correctly described the trend for the concentration of sugars in the leaves and the phloem sieve tubes as decreasing to 8 hours and then increasing, while some candidates described the concentration of sugars being higher in the leaves than in the phloem sieve tubes over 24 hours. A few candidates incorrectly stated a decrease in the concentration of sugars to 15 hours, and a few candidates did not state any time periods.

(iii) The majority of candidates suggested that sugar was not produced when the plant was in the dark and that it was produced when the plant was in the light and some candidates linked this to the concentration of sugars found in the leaves in the dark and in the light. Most candidates needed to make a suggestion to explain the concentration of sugars in the phloem sieve tubes in the dark and in the light.

(iv) Many of the candidates correctly used the graph to find the concentration of sugars in the leaves at 20 hours and used the figure in **Table 1.3** for the concentration of sugars in the leaves at 15 hours. They showed the concentration of sugars at 20 hours minus the concentration of sugars at 15 hours divided by the concentration of sugars at 15 hours and then multiplied by 100 to calculate the percentage increase in the concentration of sugars in the leaves between 15 and 20 hours. The most common errors were not reading off the concentration of sugars at 20 hours accurately from the graph and using the figure for the concentration of sugars at 24 hours instead of 15 hours.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells and used most of the space provided. The majority of candidates gained credit for carefully following the instructions and drawing the region of the organ on **L1**, as indicated in **Fig. 2.1**. The stronger candidates gained credit for drawing the correct pattern of vascular bundles and an epidermis with two lines

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containing trichomes. The majority of candidates used a label line to correctly label a vascular bundle.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin continuous lines which joined up precisely and used most of the space provided. The majority of candidates were able to draw a line of four adjacent xylem vessel elements with double lines representing the walls. The stronger candidates showed the xylem vessel elements with a thick wall and the correct shape. Most candidates used a label line to correctly identify the wall of one xylem vessel element. The most common error was to draw two lines for the wall of each xylem vessel element very close together, or to draw the inner line as a circle.

(iii) Some candidates correctly identified the plant organ on **L1** as a stem because of the number or arrangement of vascular bundles.

(b) The majority of candidates identified two observable differences between the section on **L1** and the section in **Fig. 2.2** using only observable differences. Most candidates stated that there were trichomes present on **L1** but absent in **Fig. 2.2** and that **L1** had cells in the centre whereas in **Fig. 2.2** the centre did not contain cells. Many candidates stated that the shape of the section on **L1** was square and in **Fig. 2.2** was a circle or that **L1** contained bulges at the corners that were absent in **Fig. 2.2**.

Credit was not awarded to candidates when structures that were not observable were included. For example, when the centre was referred to as a vacuole or the whole section was referred to as a cell. Some candidates identified more than two observable features but did not gain credit for this.

(c) (i) The majority of candidates correctly determined the number of eyepiece graticule units (30) present in one division of the stage micrometer and showed the division of one division on the stage micrometer by the number of eyepiece graticule units (30). Most candidates correctly showed how to calculate the actual length of one eyepiece graticule unit in micrometres.

(ii) Most candidates correctly measured the width of the tissue between the arrows on **Fig. 2.4** using the eyepiece graticule placed across the figure and many candidates showed the multiplication of the number of eyepiece graticule units by the actual length of one eyepiece graticule unit, calculated in **Question 2(c)(i)**, to calculate the actual width of the tissue between the arrows in **Fig. 2.4**.

(iii) Some candidates correctly suggested measuring at least two different widths of the tissue in **Fig. 2.4** and calculating the mean width of the tissue.

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Paper 9700/35
Advanced Practical Skills 1

Key messages

Candidates should be given the opportunity to experience a variety of practical work throughout the course, to develop the skills that can be applied to the requirements of the exam.

Candidates demonstrated that they could follow instructions, skilfully carry out an investigation, record the results in an appropriate table and estimate the percentage concentrations of glucose in **R1** and **S1**.

Candidates should be encouraged to think carefully about the investigation they have carried out and practice applying their knowledge about the topic when suggesting a reason for their results. Where the question stated, 'Suggest a reason for the percentage concentrations of glucose estimated in **R1** and **S1**', the candidate needed to make sure they gave reasons as to why the estimates for **R1** and **S1** are different, using the information given and their knowledge about diffusion.

Candidates should be encouraged to observe fine detail when viewing slides under a microscope or on a photomicrograph. They should include such detail when producing diagrams. For example, the thickness of xylem vessel element walls in high power diagrams, and the arrangement and proportions of vascular tissue in a plan diagram.

General comments

In general, many candidates demonstrated that they had a good understanding of the skills required. There was good discrimination between the weaker and more able candidates. The majority of candidates showed that they were familiar with the use of the microscope.

Comments on specific questions

Question 1

(a) (i) The majority of candidates were able to carry out a serial dilution of 1.0% glucose solution, showing the correct concentration below each beaker (0.5, 0.25, 0.125 and 0.0625%) and transferring 10 cm^3 of the previous concentration to the next beaker and adding 10 cm^3 of distilled water to each beaker. A few candidates carried out a serial dilution by a factor of 10.

(ii) The majority of candidates organised their results clearly by presenting a ruled table and included the heading for percentage concentration of glucose and the heading for time and seconds. They gained credit for recording the time to the first colour change for all the concentrations of glucose made and for recording results which showed that the time to the first colour change for the highest concentration of glucose was shorter than the time to the first colour change for the lowest concentration of glucose. Credit was awarded to candidates for recording time in whole seconds. Many candidates repeated the investigation several times but did not gain any credit for this.

(iii) The majority of candidates recorded a time to first colour change for **R1** and **S1**.

(iv) Most candidates used their results from **Question 1(a)(ii)** and **Question 1(a)(iii)** to correctly estimate the percentage concentration of glucose in **R1** and **S1**.

(v) A few candidates correctly stated that the dialysis tubing containing **R** had a greater concentration gradient between the glucose solution inside the dialysis tubing and the water surrounding it than

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the dialysis tubing containing **S** and that glucose molecules in **R** had diffused out of the dialysis tubing faster than glucose molecules in **S**. Most candidates explained how they compared the time to first colour change for **R1** and **S1** with the time to first colour change for the concentrations made in **Question 1(a)(i)** to estimate the concentration of glucose in **R1** and **S1** but did not suggest a reason for the difference in concentration between **R1** and **S1**.

(vi) A few candidates correctly calculated the average rate at which the percentage concentration of glucose is increasing in the water surrounding the dialysis tubing containing **R** and gave their answer to two significant figures. The majority of candidates correctly selected the estimate for **R1** in **Question 1(a)(iv)** but divided the concentration for **R1** by the time recorded for **R1** in **Question 1(a)(iii)** instead of the time the dialysis tubing containing **R** was left in distilled water (15 minutes).

(vii) Most candidates suggested two modifications to the investigation to obtain a more accurate estimate for the concentration of glucose in sample **R1**. Many candidates correctly described using concentrations with narrower intervals and the stronger candidates stated concentrations both sides of their estimate in **Question 1(a)(iv)** as examples of the concentrations to use. Many responses suggested repeating the whole experiment and some gained credit for suggesting the calculation of a mean.

(viii) The majority of candidates correctly stated the type of error as systematic and some correctly described that there would be no effect on the results.

(b) (i) The majority of candidates used the headings given in the table to correctly label the x-axis as type of sugar, and the y-axis as mass of sugar / g per 100 g fruit. They labelled each bar clearly with the type of sugar (glucose, fructose and sucrose) and the type of fruit (apple or pineapple) or included a key and drew bars of equal width on the x-axis. The majority of candidates used a scale of 2 g per 100 g fruit to 2 cm for the y-axis and plotted each bar accurately with ruled lines for the bars so that the vertical lines joined with the horizontal lines precisely.

(ii) Most candidates correctly showed how to calculate the percentage difference in the mass of sucrose per 100 g of pineapple compared to the mass of sucrose per 100 g of apple. They showed the mass of sucrose per 100 g of pineapple minus the mass of sucrose per 100 g of apple divided by the mass of sucrose per 100 g of pineapple and then multiplied by 100. The most common error was showing the mass of sucrose per 100 g of pineapple minus the mass of sucrose per 100 g of apple and multiplied by 100.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells and used most of the space provided. The majority of candidates gained credit for carefully following the instructions and drawing the region of the stem on **M1**, as indicated in **Fig. 2.1**. The stronger candidates gained credit for drawing the wavy outline of the stem and the correct proportion of vascular bundles to the width of the cortex. The majority of candidates used a label line to correctly label the xylem.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin continuous lines which joined up precisely and used most of the space provided. The majority of candidates were able to draw a group of four adjacent xylem vessel elements with double lines representing the walls. The stronger candidates showed the xylem vessel elements with a thick wall. Most candidates used a label line to correctly identify the wall of one xylem vessel element. The most common error was to draw two lines for the wall of each xylem vessel element very close together or to draw the inner line as a circle.

(b) The majority of candidates displayed three observable differences in a table with a heading for **M1** and a heading for **Fig. 2.2**. Most candidates stated that there were more vascular bundles in **M1** than in **Fig. 2.2** and that the vascular bundles were closer to the epidermis in **M1** than in **Fig. 2.2**. Many candidates described the shape of the section on **M1** as circular and the section in **Fig. 2.2** as a pentagon or having five sides and that **M1** contained cells in the centre whereas the centre in **Fig. 2.2** did not contain cells.

Credit was not awarded to candidates when structures that were not observable were included, for example, the presence or absence of a cuticle or stomata, or the whole section was referred to as a cell. Some candidates identified more than three observable features but did not gain credit for this.

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(c) (i) The majority of candidates correctly determined the number of eyepiece graticule units (19) present in one division of the stage micrometer and showed the division of one division on the stage micrometer by the number of eyepiece graticule units (19). Most candidates correctly calculated the actual length of one eyepiece graticule unit in micrometres and gave their answer to three significant figures.

(ii) Most candidates correctly measured the length of the vascular bundle on **Fig. 2.4** using the eyepiece graticule placed across the figure and the majority of candidates showed the multiplication of the number of eyepiece graticule units by the actual length of one eyepiece graticule unit, calculated in **Question 2(c)(i)**, to calculate the actual length of the vascular bundle in **Fig. 2.4**.

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Paper 9700/36
Advanced Practical Skills 2

Key messages

Candidates should be given the opportunity to experience a variety of practical work throughout the course, to develop the skills that can be applied to the requirements of the exam.

Candidates should be aware that within an investigation, they should be able to draw a graph clearly and accurately with the independent variable on the x-axis and the dependent variable on the y-axis. Each axis should be labelled to match the relevant table headings, including units where appropriate, and using a scale where both axes should use most or all of the grid available. If there is more than one line on the graph each should be identified, either on the graph or by means of a key. All the graph points should be plotted accurately using a sharp pencil, as a small cross or a small dot in a circle. The plotted points of the graph should be connected with a clear, sharp and unbroken line, either as a line of best fit or a smooth curve or with ruled straight lines joining the points.

General comments

In general, many candidates demonstrated that they had a good understanding of the skills required. There was good discrimination between the weaker and more able candidates. The majority of candidates showed that they were familiar with the use of the microscope.

Comments on specific questions

Question 1

(a) (i) Many candidates organised their results clearly by presenting a ruled table. The strongest responses included the heading for immobilised yeast cells and 'free' yeast cells and the heading for the dependent variable as time and the appropriate units, seconds. The best answers included a heading to indicate when the sample was taken, at 1 minute, then 2, 3, 4 and 5 minutes. Most candidates recorded a time for each sampling time, for both the beads and the 'free' yeast cells and the times showed the correct trend. The stronger candidates recorded their results as whole seconds.

(ii) Some candidates correctly described the trend for the immobilised yeast cells and for the 'free' yeast cells as over the 5 minutes the time to first colour change decreased. The stronger candidates also correctly stated that the times for the 'free' yeast cells decreased more than for the immobilised yeast cells. Credit was given to candidates who referred to the data in **Question 1(a)(i)** to show evidence for their statements.

(iii) Most candidates correctly suggested an appropriate control for the experiment as using boiled and cooled enzyme or replacing the yeast cell suspension with water.

(iv) Some candidates correctly suggested that the samples from **F** had to be tested for the presence of reducing sugars immediately as the reaction between the yeast cells and sucrose was still continuing and the sucrose was still being hydrolysed.

(v) Some candidates correctly explained that the action of stirring was to ensure a thorough mixing of the yeast and sucrose or even mixing of the reducing sugars when taking the samples. The stronger candidates made it clear that they were describing the stirring of the yeast or sucrose or the reducing sugars.

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(vi) Some candidates correctly stated that a possible source of error when measuring the time to first colour change for 'free' yeast cells was that the timer was also being used for timing the removal of the samples. The stronger candidates correctly suggested an improvement to the procedure was to use two separate timers, one to time the removal of the samples and the other to use for measuring the time to the first colour change.

(b) (i) Most candidates correctly used the headings given in **Table 1.2** to label the x-axis (pH) and the y-axis (activity of catalase / arbitrary units). Some candidates labelled the incorrect axis or gave incomplete headings. The stronger candidates used a scale of 1.0 to 2 cm for the x-axis, and a scale of 20 to 2 cm for the y-axis. Many candidates plotted all the points accurately and joined the points with a thin line. The most common error was not identifying the lines or not using the correct scale for the y-axis.

(ii) Some candidates stated appropriate conclusions about how pH affected the activity of immobilised catalase compared to 'free' catalase by correctly stating that between pH5 and ph9 there was higher activity with immobilised catalase compared to the 'free' catalase and that both immobilised catalase and 'free' catalase had the same optimum pH of 7. The stronger candidates stated that between pH7 and pH9 there was a greater decrease in activity for the 'free' catalase compared to the immobilised catalase.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the whole section on **N1**. Many candidates gained credit for drawing at least three layers of tissue, for drawing the epidermis as two lines and including at least a minimum number of vascular bundles. Many candidates used a label line and label to identify the phloem.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin lines which joined up precisely and used most of the space provided. Many candidates were able to draw four adjacent cortex cells with each cell touching at least two of the other cells, with double lines representing the walls. The stronger candidates drew cells with more than four sides. The most common error was to draw lines that did not meet up precisely or were too thick. Many candidates used a label line and a label to identify the cell wall of a cortex cell.

(b) Many candidates correctly identified three observable differences between the section on **N1** and the section in **Fig. 2.1**. Included in these differences were that the vascular bundles on **N1** were located in a ring near the periphery while in **Fig. 2.1** they were scattered throughout the stem**,** there were fewer vascular bundles on **N1** than in **Fig. 2.1** and the cortex cells on **N1** were larger than the cortex cells in **Fig. 2.1**.

(c) (i) Many candidates correctly decided to measure at least three diameters of the stem and then found the mean diameter by adding up these measurements and dividing by the number of measurements and showing the appropriate units.

(ii) Some candidates correctly measured the length of the scale bar and showed the appropriate units. The stronger candidates divided the mean diameter found in **Question 2(c)(i)** by the length of the scale bar and multiplied by 310 to find the mean actual diameter of the section.

(iii) Many candidates correctly showed their answer to **Question 2(c)(i)** divided by their answer to **Question 2(c)(ii)** and gave their answer to the nearest whole number.

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Paper 9700/37
Advanced Practical Skills 1

There were too few candidates for a meaningful report to be produced.

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Paper 9700/38
Advanced Practical Skills 2

Key messages

Candidates should be given the opportunity to experience a variety of practical work throughout the course, to develop the skills that can be applied to the requirements of the exam.

Candidates should be aware that within an investigation, they should be able to draw a graph clearly and accurately with the independent variable on the x-axis and the dependent variable on the y-axis. Each axis should be labelled to match the relevant table headings, including units where appropriate, and using a scale where both axes should use most or all of the grid available. If there is more than one line on the graph each should be identified, either on the graph or by means of a key. All the graph points should be plotted accurately using a sharp pencil, as a small cross or a small dot in a circle. The plotted points of the graph should be connected with a clear, sharp and unbroken line, either as a line of best fit or a smooth curve or with ruled straight lines joining the points.

General comments

In general, many candidates demonstrated that they had a good understanding of the skills required. There was good discrimination between the weaker and more able candidates. The majority of candidates showed that they were familiar with the use of the microscope.

Comments on specific questions

Question 1

(a) (i) Many candidates organised their results clearly by presenting a ruled table. The strongest responses included the heading for immobilised yeast cells and 'free' yeast cells and the heading for the dependent variable as time and the appropriate units, seconds. The best answers included a heading to indicate when the sample was taken, at 1 minute, then 2, 3, 4 and 5 minutes. Most candidates recorded a time for each sampling time, for both the beads and the 'free' yeast cells and the times showed the correct trend. The stronger candidates recorded their results as whole seconds.

(ii) Some candidates correctly described the trend for the immobilised yeast cells and for the 'free' yeast cells as over the 5 minutes the time to first colour change decreased. The stronger candidates also correctly stated that the times for the 'free' yeast cells decreased more than for the immobilised yeast cells. Credit was given to candidates who referred to the data in **Question 1(a)(i)** to show evidence for their statements.

(iii) Most candidates correctly suggested an appropriate control for the experiment as using boiled and cooled enzyme or replacing the yeast cell suspension with water.

(iv) Some candidates correctly suggested that the samples from **F** had to be tested for the presence of reducing sugars immediately as the reaction between the yeast cells and sucrose was still continuing and the sucrose was still being hydrolysed.

(v) Some candidates correctly explained that the action of stirring was to ensure a thorough mixing of the yeast and sucrose or even mixing of the reducing sugars when taking the samples. The stronger candidates made it clear that they were describing the stirring of the yeast or sucrose or the reducing sugars.

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(vi) Some candidates correctly stated that a possible source of error when measuring the time to first colour change for 'free' yeast cells was that the timer was also being used for timing the removal of the samples. The stronger candidates correctly suggested an improvement to the procedure was to use two separate timers, one to time the removal of the samples and the other to use for measuring the time to the first colour change.

(b) (i) Most candidates correctly used the headings given in **Table 1.2** to label the x-axis (pH) and the y-axis (activity of catalase / arbitrary units). Some candidates labelled the incorrect axis or gave incomplete headings. The stronger candidates used a scale of 1.0 to 2 cm for the x-axis, and a scale of 20 to 2 cm for the y-axis. Many candidates plotted all the points accurately and joined the points with a thin line. The most common error was not identifying the lines or not using the correct scale for the y-axis.

(ii) Some candidates stated appropriate conclusions about how pH affected the activity of immobilised catalase compared to 'free' catalase by correctly stating that between pH5 and ph9 there was higher activity with immobilised catalase compared to the 'free' catalase and that both immobilised catalase and 'free' catalase had the same optimum pH of 7. The stronger candidates stated that between pH7 and pH9 there was a greater decrease in activity for the 'free' catalase compared to the immobilised catalase.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the whole section on **N1**. Many candidates gained credit for drawing at least three layers of tissue, for drawing the epidermis as two lines and including at least a minimum number of vascular bundles. Many candidates used a label line and label to identify the phloem.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin lines which joined up precisely and used most of the space provided. Many candidates were able to draw four adjacent cortex cells with each cell touching at least two of the other cells, with double lines representing the walls. The stronger candidates drew cells with more than four sides. The most common error was to draw lines that did not meet up precisely or were too thick. Many candidates used a label line and a label to identify the cell wall of a cortex cell.

(b) Many candidates correctly identified three observable differences between the section on **N1** and the section in **Fig. 2.1**. Included in these differences were that the vascular bundles on **N1** were located in a ring near the periphery while in **Fig. 2.1** they were scattered throughout the stem**,** there were fewer vascular bundles on **N1** than in **Fig. 2.1** and the cortex cells on **N1** were larger than the cortex cells in **Fig. 2.1**.

(c) (i) Many candidates correctly decided to measure at least three diameters of the stem and then found the mean diameter by adding up these measurements and dividing by the number of measurements and showing the appropriate units.

(ii) Some candidates correctly measured the length of the scale bar and showed the appropriate units. The stronger candidates divided the mean diameter found in **Question 2(c)(i)** by the length of the scale bar and multiplied by 310 to find the mean actual diameter of the section.

(iii) Many candidates correctly showed their answer to **Question 2(c)(i)** divided by their answer to **Question 2(c)(ii)** and gave their answer to the nearest whole number.

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Paper 9700/41
A Level Structured Questions

There were too few candidates for a meaningful report to be produced.

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International Education

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Paper 9700/42
A Level Structured Questions

Key messages

1. Some candidates demonstrated good subject knowledge although they had difficulty applying it, particularly when required to interpret a reverse situation such as in **Question 1(c)(ii)**, **Question 3(a)(ii)**, **Question 6(a)** and **Question 10(c)**.

2. Some candidates needed to take more care to read the question correctly. In **Question 3(a)(iii)**, many candidates misunderstood the term 'following' and instead described the reactions leading to fructose 1,6-bisphosphate production, suggesting the question had not been read carefully enough.

General comments

Overall, the paper was accessible to all abilities and differentiated well. Many candidates could improve by giving greater detail in their answers.

Candidates should take time to engage with the information in the question stem at the start and to refer back to it when answering each new question part, such as in **Question 5(b)(ii)**. For all of **Question 5**, candidates who had read through and then referred to the information and context provided were awarded more credit across the question.

Comments on specific questions

Question 1

(a) Most candidates correctly identified the three answers from **Fig. 1.1**, which outlined the effects on rice plants of growing in flooded fields. Substance **A** was sometimes incorrectly named as carbon dioxide or nitrates rather than oxygen. A very small number of candidates gave ethanal instead of ethanol, and a minority stated carbon dioxide as the waste product, **B**. For tissue **C** (aerenchyma), common errors included naming vascular tissue – xylem or phloem. More able candidates correctly identified oxygen, ethanol, and aerenchyma, while weaker answers included chemical formulae instead of names as required, vague terms such as 'alcohol,' or incorrect tissues. Phonetic spellings of aerenchyma were accepted.

(b) Candidates who identified substance **B** as ethanol did not always recognise that ethanol dehydrogenase is produced specifically in response to high ethanol concentrations. Many answers focused on the idea of 'ethanol tolerance' rather than describing the mechanism. This meant that most candidates were not successful at answering this question. Less able candidates incorrectly suggested that ethanol could diffuse out of cells or alter osmotic potential.

(c) (i) Most candidates interpreted the graph effectively, understood the general trend, and stated the positive relationship between gibberellin concentration and stem length, usually quoting correct units. Many omitted supporting data and some overlooked that the x-axis began at 1 au. Misread numerical values were common. A small number of candidates incorrectly answered that this relationship was directly proportional.

(ii) Some candidates were familiar with rice plant growth and the challenges presented to a plant that grows in a partially submerged field. Many candidates described how ethylene affects ABA and gibberellin and needed to go on to fully explain the physiological consequences for the plant. Stronger responses linked ethylene production in flooded rice fields to ABA breakdown, activation

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of gibberellin, and increased stem elongation. A minority of more able candidates extended this by explaining the advantage of lifting leaves or flowers above water to allow photosynthesis, pollination, or gas exchange. Common mistakes included stating only that the 'plant grows above the water', without specifying which structures, or giving unrelated facts about stomatal closure. Some candidates incorrectly thought that gibberellin concentration would increase.

Question 2

(a) This straightforward AO1 question required the explanation of genetic terms and was answered well. Most candidates were able to recall that a gene is a section of DNA that codes for a polypeptide and that the phenotype describes observable characteristics. Quite a few incorrectly suggested that a gene codes for an amino acid. Genotype definitions were sometimes too vague and focused on genes rather than alleles; some who focused on alleles needed to link this to 'the organism' or 'for one gene'.

(b) This question was well answered by the few candidates who knew that a monohybrid cross produced an F1 generation from a cross between a homozygous dominant and a homozygous recessive parent. These responses went on to achieve full credit. There were some good clear outlines, starting with two homozygous parents, one dominant and one recessive, producing heterozygotes that when crossed gave the correct percentages of genotypes in the F2 generation. A common error was to describe both options of test crosses and include a heterozygote parent as an F1 parent. Quite a few could then logically state that the F2 generation would result from a crossing of the F1 offspring. Some candidates misinterpreted the first bullet point of the question, which used the command word 'outline' and drew out a genetic diagram. This could not be credited unless it had clear annotations of the process shown, which was rarely the case. The second part of the question had the term 'genotype' in bold; some candidates missed out on credit as they only gave the expected percentages of the phenotypes in the F2 generation. Another common error was to not cross parents or individuals but instead alleles. There were lots of instances of dihybrid ratios in an attempt to state the genotype percentages in the F2 generation.

Question 3

(a) (i) This was one of the hardest questions that the majority of candidates found challenging. Candidates who focused on the prompt of the question about the presence of glucose and followed the diagram in **Fig. 3.1** in a step-by-step manner gained full credit. Some candidates who focused on glucose were not precise enough with their terminology for the entry of glucose into the cytoplasm. The diagram did not show evidence of ATP use, so it had to be the process of diffusion. Candidates should always name the process of transport into and out of cells. Many simply repeated that glucose was phosphorylated and did not focus on enzyme **B** losing its phosphate.

The most common points awarded credit were stating that enzyme **B** binds to lactose permease and that this would change its shape and functioning, both familiar concepts in the control of gene expression in the *lac* operon. The main key sources of error were misreading the question and not describing the diagram with precise terminology. Many candidates needed to focus on the presence of glucose and instead gave long descriptions of the effect of lactose on gene expression, which earned no credit. Others attempted to combine glucose uptake with *lac* operon regulation, leading to confused answers. Some repeated generic cell signalling content, which was also not credited.

(ii) Candidates found this question challenging. Although many recognised the idea of avoiding energy waste; few recognised that this question tested the understanding of why the *lac* operon is inducible and only expressed when needed. More able candidates went on to give reasons why energy is saved, for instance, that transcription of the structural genes is reduced or that lactose must be broken down before it can be respired, making glucose a better option.

(iii) Many candidates found this question more straightforward and gained full credit for outlining events in glycolysis. The key problem was not reading the question carefully and writing about events before fructose 1,6-bisphosphate formation. Other mistakes in accuracy included: not splitting into two TP, reducing or hydrogenating TP and producing reduced NADH. Candidates should be encouraged to use syllabus terminology, e.g. reduced NAD and not NADH.

(b) (i) Most candidates gained some credit. Many found the data interpretation difficult. Some candidates either misread the graph or did not attempt to use numerical values. Many, instead of describing

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the trend of each diet from the starting point of 50%, compared the two diets. Candidates should always quote figures and units when describing data.

(ii) This question proved to be very challenging. Those candidates who focused on the context of selection as given in the question, correctly used the term selection pressure and identified the presence of lactose being this driving factor. Some also went on to give the selective advantage that *lac*$^+$ mice would have. Answers were often confused. Some candidates thought the question referred to mice. Few recognised that lactose was the selection pressure and that *lac*$^+$ bacteria survived because they could transport in and metabolise lactose when glucose had run out as shown in **Question 3(a)(i)**. Many incorrectly discussed structural gene regulation instead of applying principles of natural selection.

Question 4

(a) Most candidates gained credit for identifying mutation as the process for a bacterium to become resistant. More able candidates correctly named other ways to receive an antibiotic-resistant gene, either by horizontal gene transfer or types of horizontal gene transfer. A common incorrect answer was to consider the reasons for increased mutation rates and horizontal gene transfers by incomplete antibiotic courses or overuse. Vertical gene transfer was not relevant because the question asked for the ways a single bacterium would become resistant.

(b) This was generally well answered, with many candidates recognising its role in the production of new antibiotics. Some incorrectly suggested the scientists would reverse the resistance mutation in bacteria with gene editing or genetic engineering.

(c) Stronger candidates recognised that for this natural selection question, they needed to use terms such as selection pressure and directional selection. They also structured their answer into the common framework for all natural selection answers. Many candidates noted that resistant bacteria survive and reproduce. A number incorrectly stated that bacteria divide by mitosis. It was also common to see resistance traits being passed on and not the gene or allele for resistance.

Question 5

(a) The majority of candidates identified *Taq* polymerase as being a requirement of the PCR process. Credit was given for explaining that it functions at high temperatures and synthesises double-stranded DNA. Some candidates wrote just ‘DNA polymerase’ and this was not specific enough. Many candidates needed to qualify ‘nucleotides’ with DNA. More able candidates used the term ‘dNTPs’. Common incorrect substances stated were DNA ligase, helicase, restriction enzymes, reverse transcriptase and marker genes, indicating that some candidates struggled to differentiate the various genetic technologies on the syllabus. The main error was to write that the role of dNTPs was to make double-stranded DNA, which is the role of *Taq* polymerase. The dNTPs simply make hydrogen bonds as they join as complementary base pairs. Consequently, the other common mistake was to write that *Taq* polymerase made hydrogen bonds between bases instead of phosphodiester bonds between adjacent nucleotides.

(b)(i) Most candidates understood that the DNA ladder is there for comparison and identification purposes. The majority of these responses needed to clarify that it enables the fragment number or length to be known.

(ii) Credit was commonly achieved for recognising that PCR amplifies DNA and electrophoresis separates fragments. Those who answered this as separate parts, made it clear which process they were referring to. While many candidates recognised that PCR was used to amplify the DNA, very few could interpret the information given in the question sufficiently to realise that it was also critical for producing DNA fragments of a length short enough to allow for the sequencing process. A few responses gave the final point of electrophoresis allowing the identification of fragment length or number.

(c) Candidates struggled to answer this question to achieve the answer of 3.4×10^{10}. Very few calculated their answer to the correct number of significant figures. The most common incorrect answer was 70, indicating that many did not understand how a repeated doubling works mathematically. Some candidates needed to make effective use of their calculator’s exponential function, and some who did achieve the correct number were then unable to convert their answer to standard form.

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(d) Many candidates gained credit for noting the expense of either screening or treatment. Some responses correctly referred to early diagnosis or improved life expectancy and the possibility of inaccurate tests. Some candidates struggled to engage with the information given in the question, which clearly stated that screening is for newborns, as very many gave concerns about termination of pregnancies as a potential consequence of screening. Candidates need to be aware that simply repeating statements from the question verbatim will not be credited.

Question 6

(a) Overall, this question was answered less well. Candidates showed a good understanding of the process and scored some credit. Poor use of terminology prevented them from scoring higher in this question. Many needed to use the information in the diagram to structure their answer and often gave irrelevant and incorrect facts. Another common mistake was for candidates to use the appropriate biology to describe what happens when the enzymes are functioning correctly, without going on to suggest what happens when there is insufficient PI3K, therefore not answering the question. Candidates stated that PKB is not produced rather than stating it is not activated or stimulated. They referred to the cell membrane rather than the cell surface membrane and wrote that vesicles bind instead of fuse with the membrane. There was no mention of the process of uptake of glucose, in this instance by facilitated diffusion. Candidates should always be precise with the process of movement across a membrane. A few needed to use the term concentration for glucose, instead of using level, which is rarely credited. A number of responses started with reduced glucose uptake without explaining the sequence involving PI3K. Some candidates showed confusion about PI3K's role, incorrectly stating that it synthesises insulin or breaks down glucose. Others gave very general descriptions of insulin and control of blood sugar concentrations.

(b) This AO1 question was well answered with many candidates who had a very good understanding of the functioning of a biosensor gaining full credit. Some weaker responses wrote about urine rather than blood despite blood being given in the stem of the question. Candidates did not always understand that a flow of electrons results in an electric current and often a lot of detail on the reactions involving hydrogen peroxide was included. Many referred to flow of electrons instead of linking the size of the current to the glucose concentration in the blood. Some candidates confused biosensors with colorimetric strips and described colour changes.

Question 7

(a) (i) This was found to be the hardest question on the paper and few scored credit. The majority of candidates knew that the plant was getting minerals or mineral ions from the insects and needed to link this to these substances being lacking in the soil to be credited. Many candidates gave the vague term of nutrients, which could include glucose and therefore not be correct. Very few knew that these plants are located in shady places.

(ii) The majority of candidates gave the correct answer with a very few incorrectly naming pigments as the reason for the red colour.

(iii) Many candidates recognised the need to prevent accidental closure as reducing waste of energy/ATP. Weaker candidates incorrectly stated that the two touches ensure the insect is large enough.

(iv) This was well answered with stronger responses referring to digestive enzymes and absorption of released nutrients. Vague references to breaking down and getting nutrients were not credited as the use of biological terms was required. Some explanations for the trap remaining closed were simplistic, focusing only on preventing escape.

(b) This was a challenging question for most candidates. A good proportion gave the reason for the refractory period as making sure the impulses are unidirectional; some others described making impulses discrete. Stronger candidates also knew that the frequency of the impulses was limited by the refractory period. There were many incorrect ideas about causing repolarisation.

Question 8

(a) Most candidates scored well on this question and could transfer their experience of similar questions to the context of orangutans in the rainforest habitat. Generic responses which included

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captive breeding programmes, banning hunting, raising awareness and research were quite common. Fewer responses suggested limiting palm oil plantations as a measure that relates specifically to the context of orangutans in Borneo. There were some candidates who gave several examples of captive or assisted breeding without reference to other methods, thus limiting the credit they could achieve.

(b) This was a straightforward AO1 question. Many candidates understood and could list the levels at which biodiversity can be assessed. Commonly, responses were limited to descriptions of how species richness and abundance could be considered and a significant number suggested the ranks of the hierarchical classification system or described sampling methods.

(c) (i) Most candidates correctly calculated the two missing values; the most common mistake was miscalculating the value for hazel. Here, the answer of 0.2030 was given, where incorrect rounding was followed with the addition of a zero to match the number of decimal places provided in the rest of the column. Addition of the column was usually correct. Some candidates needed to write their answer to 4 decimal places to match the table column.

(ii) The vast majority of candidates subtracted their previously calculated value from 1 and therefore achieved credit.

(iii) Candidates usually understood that the correct *D* value indicated a high diversity. Candidates should use the term 'high', rather than less appropriate terms such as 'strong' or 'good' diversity, or that it is biodiverse. Most explained their conclusion by stating that the *D* value is close to 1 or higher than 0.5.

Question 9

(a) (i) Explanations of the AO1 terms 'absorption spectrum' and 'action spectrum' proved to be an area for improvement for candidates. Many candidates needed to know the difference between an action and an absorption spectrum. A small number recognised that the absorption spectrum is for one pigment or that a spectrum meant different wavelengths of light.

(ii) This was a very challenging question that required a clear understanding that the absorption spectrum was for one pigment but that the action spectrum and the rate of photosynthesis was due to many different pigments. Those candidates who took note of the command word 'explain' in the question could provide a full explanation for the difference in terms of accessory pigments and their ability to absorb wavelengths of light that chlorophyll *a* cannot. A minority could explain the rate of photosynthesis in terms of energy being passed to the reaction centre and the subsequent light dependent reactions. The majority of candidates did not understand this question and instead of offering an explanation for the difference between the absorption spectrum and the action spectrum, described the similarities or differences.

(b) (i) This question was high scoring for many candidates, almost all describing the trend and identifying enzymes denaturing as the reason for the decrease in the rate of photosynthesis. When suggesting the optimum temperature, it was common to give the range of 28 to 30°C, therefore missing out on credit for being outside the acceptable range of 28.5–29.5°C. Although the increase in energy of particles was often provided as the reason for the increase in rate, fewer candidates were precise with their description of enzymes or substrates having more kinetic energy, therefore missing out on the credit here too. Data was frequently quoted, usually accurately and with the correct units. There were a small number of candidates who described the respiration graph. There were some who compared the two graphs rather than linking the temperature to enzyme activity.

(ii) The majority of responses gained the credit here for the unit. The stronger candidates added their two values taken from the graph together to gain full credit for the question, but many subtracted them. A range of incorrect answers were given. Some graph readings were inaccurate. Some did not quote the unit at all.

Question 10

(a) Most candidates described the myelin sheath as an insulator and recognised that saltatory conduction increases conduction speed. Stronger responses included the role of the nodes of Ranvier as the only sites of action potential generation and the formation of long local circuits. Less

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able candidates referred incorrectly to impulses rather than action potentials jumping, or stated that the action potential jumps without explaining where or why.

(b) Many candidates used correct terms such as sarcolemma, sarcoplasm, depolarisation, T-tubules, and sarcoplasmic reticulum. Care must be taken when describing the movement of sodium ions across the membrane to ensure it is not stated as 'into the membrane or sarcolemma'. Good answers clearly described acetylcholine binding, sodium ion influx, depolarisation spreading down T-tubules, and voltage-gated calcium ion channels opening causing the release of Ca^{2+} into the sarcoplasm. Errors included confusing postsynaptic membranes with the sarcolemma, omitting that calcium ion channels are voltage-gated, or stating incorrect ion symbols. Candidates must take care to read the question carefully to allow them to identify which part of the process is being examined. Many candidates included a description of the binding of calcium ions to troponin which was stated in the question.

(c) This question required the understanding of ATP's role in sarcomere function. More able candidates explained that low glucose concentration reduces ATP production, leading to fewer cross-bridges being broken and weaker power strokes, reducing sarcomere shortening. A few mentioned reduced Ca^{2+} reuptake into the sarcoplasmic reticulum and sustained contraction. Many candidates answered only in general terms or focused on overall muscle contraction rather than the sarcomere specifically. The main misconception was that ATP was needed in cross-bridge formation or that ATP hydrolysis broke the cross-bridge. The correct sequence is the binding of ATP to the myosin head causes a conformational change that breaks the cross-bridge and then the hydrolysis of ATP follows this to release energy to return the myosin head to its original position.

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Key messages

There were many excellent responses written by well-prepared candidates. There were also several areas identified in which candidates could improve. In **Question 3(b)**, many confused the lines on the graph for carotenoids and chlorophyll *b* and showed limited ability to read figures from the graph accurately. **Question 2** exposed weakness in the understanding of the principles of classification, and **Question 4** showed that many candidates had an insecure understanding of the following key distinctions with wide relevance to both genetics and selection:

- genetic resistance versus acquired immunity
- gene versus allele
- genetic drift versus selection.

Candidates also need to be aware that ATP does not get transported around an organism and energy is not made or produced or destroyed (**Question 7**).

General comments

Many strong candidates showed all of the following skills:

- reading and interpreting questions carefully
- selecting relevant facts and ideas from their syllabus knowledge
- using the question context material creatively to draw comparisons, making analytical deductions and suggesting explanations
- expressing their ideas in legible, intelligible English.

Weaker scripts generally showed poor development of one or more of these four skills, plus a lower level of background knowledge.

Some questions where most candidates performed well were genetics (**Question 1**), calculating an R_f value (**Question 3(a)(i)**), comparing the endocrine and nervous systems and muscle contraction (**Question 5**), oxidative phosphorylation (**Question 7(b)**) and biosensors (**Question 9(b)**).

Tasks that all candidates found challenging were comparing similarities and differences in absorption spectra (**Question 3(b)**), interpreting a novel selection context and graph (**Question 4**), interpreting a novel conservation context (**Question 6**) and suggesting why countries differ in whether or not they grow GM soybean (**Question 8(c)**).

Comments on specific questions

Question 1

(a) (i) Strong candidates listed all four genotypes of a guinea pig with short black fur whilst weaker answers often gave three or fewer.

(ii) Many answers gave a guinea pig with long chocolate fur as the male required for a test cross. Occasional wrong answers were ‘short black’ or writing a genotype instead of a phenotype.

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(b) Many candidates completed the Punnett square with all four gametes from each heterozygous parent and correctly derived the offspring genotypes. These candidates were able to deduce the correct 9:3:3:1 ratio. The question included the prompt 'You should include a key to link phenotypes to genotypes' as omitting to do this is a common error in the presentation of genetic crosses. Despite the prompt, many answers were without a key and missed out on credit. Candidates who succeeded wrote the initials of the phenotypes in the Punnett square under the genotypes (SC for short chocolate, LB for long black, etc.) or they provided a key of symbols (a star, a heart, a circle and a square for instance) to mark each of the four offspring phenotypes in the boxes of the Punnett square. Some candidates used colours to shade the boxes according to which of the four phenotypes it represented.

The requirement is for the candidate to work in a sequence of logical steps, showing how during the examination they have reasoned out the ratio of phenotypes from their genotypes. Candidates who do not do this may make multiple errors. For example, if they make a mistake with one of the sixteen offspring genotypes and do not work through linking genotypes to phenotypes, they may state that their working shows a 9:3:3:1 ratio when it does not, giving a second error, since the ratio a candidate writes down must match the working in their Punnett square.

(c) Correct answers referred to or named a suitable protein made by a structural gene, such as an enzyme, and related a regulatory gene to controlling the expression of other genes. Some candidates could not distinguish between a structural and a regulatory gene. Errors included stating that a regulatory gene codes for an enzyme and that only a regulatory gene has a promoter.

Question 2

(a) (i) Many candidates correctly described a structural difference, most commonly the chitin cell wall in the fungus versus the cellulose cell wall in the plant. The functional difference usually focused on the differing modes of nutrition of the two organisms, e.g. heterotrophic versus autotrophic. *Exserohilum turcicum* was described in the question as being a pathogen that lived on maize plants, causing yield reduction, hence the mode of nutrition was parasitic, not saprophytic as some candidates suggested.

(ii) Few candidates outlined the basic principles of a hierarchical classification, with species sharing sets of features being placed within a group, and groups sub-dividing into smaller groups with more specific suites of shared features. Strong answers given focused on the names of the taxonomic groups and the classification of the two species into their shared domain and different kingdoms. Some answers broke down the Latin names to illustrate the meaning of genus and species.

(b) (i) Strong candidates with good analytical skills interpreted the information in **Fig. 2.1** correctly and also followed the question rubric to explain how they used the graph to determine which parent maize variety showed the greatest resistance to infection.

Many candidates simply gave an answer with no supporting explanation and reasoning, which did not provide a sufficient response to the question. Weaker candidates needed to understand that the y-axis label, number of plants, was irrelevant, since the question asked about the parent varieties, which were not part of the F2 generation shown by the bars representing number of plants on the graph. Instead, the parent varieties were shown as arrows on the x-axis to indicate the mean percentage area of leaf damage each showed. A correct answer explained how the x-axis label, percentage area of leaf damage, related to resistance to infection, so that a lower area of leaf damage shows a greater resistance to infection. From this they deduced that SKV50 shows greater resistance. The weakest answers showed poor graph interpretation skills, confusing what was shown by the two axes.

(ii) The correct answer, 'continuous', was the most common answer. Wrong answers included discontinuous, genetic and stabilising.

(iii) Candidates who had some idea about the genetic basis of continuous variation as involving many genes and their additive effects still often struggled to present their ideas without contradicting themselves. For example, 'Many genes are located at the same locus' revealed a fundamental lack of understanding of what a gene is. The statement 'Many alleles have an additive effect' is incorrect because in a diploid organism there can only be a maximum of two alleles present for each gene. Careful wording was required to express the idea that the alleles of each gene have a small effect, but that many different genes each contribute their effect to the same trait, in this case, plant

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resistance to a fungal disease. Few candidates used a simple mathematical method to explain how if three or more genes each contribute to the same trait a range of intermediate phenotypes is possible.

Question 3

(a) (i) Nearly all candidates succeeded in calculating the R_f value.

(ii) The related explanations seen in stronger answers were that chlorophyll *a* must have been changed into phaeophytin molecules, and that **B** was in the solvent not just for a 'different length of time' (an imprecise and incomplete answer), but for a shorter length of time, hence the solvent did not have as long to travel up the chromatography plate. Candidates often stated that the chlorophyll *a* molecule split to give the two phaeophytin molecules, which was given credit as a logical deduction given the pigments shown on **B**; in fact all of the chlorophyll *a* was converted to phaeophytin *a* while only some of the chlorophyll *b* was converted to phaeophytin *b*. Many candidates simply described what they saw, for example that **A** shows chlorophyll *a* while **B** shows two types of phaeophytin, and that **B** shows a shorter solvent front. These descriptions did not gain any credit.

(iii) The most common correct answer was that a different solvent was used. Suggestions about a different type of spinach missed the point that R_f values are standard for each pigment with its fixed molecular structure regardless of where they have come from.

(b) Many candidates scored credit for referring to colours, limiting their observations to blue and red, the colours written on **Fig. 3.2**. The most common correct statement was that both pigments absorb blue light, and the second most common correct statement was that chlorophyll *a* absorbed red but carotenoids did not. A significant proportion of candidates misread the line for chlorophyll *b* as representing carotenoids and stated the opposite wrong conclusion, that both pigments absorb red. Some candidates used their knowledge of the colours of the rainbow (the visible spectrum) to describe patterns, for example that neither pigment absorbs well in green light, or that chlorophyll *a* absorbs more light in the violet region. Others had difficulty attempting to delimit the area of low green absorption using wavelength figures. Candidates were more successful at identifying peaks than ranges of low absorption, with another common correct statement involving a comparison of the highest peak value of each pigment. Some candidates needed to specify that these figures were the peak or maximum absorption for each pigment, to explain the meaningful basis of their comparison.

Candidates often provided an answer that was too short to provide enough similarities and differences to gain full credit. Many answers were imprecise, and where figures from the graph were read, they were not read in a consistent fashion, for example always to the point where absorption decreased below 3% for 'little to no' absorption, or to the top 3% of absorption for a peak. Figures were also not read to the nearest graph square with the understanding that one vertical square was equal to 3% absorption and one horizontal square was equal to 5 nm.

(c) Well-prepared candidates gave thorough answers. Weaker answers only covered part of the sequence of events, such as DELLA breakdown and PIF release, or alternatively hydrolysis of starch by amylase giving glucose for respiration in the embryo. A common omission was to explain that the gene for amylase is transcribed after PIF or that a transcription factor binds to the promoter. Some answers needed to mention the embryo as opposed to the whole seed needing the glucose from the endosperm for growth.

Question 4

(a) Candidates were asked to supply the correct terms for three descriptions. The commonest correct name given was 'allele' for 'a form of a gene'. Many also recognised 'a form of a gene that gives a phenotypic effect in a heterozygote' as 'dominant' or 'codominant'. Candidates were less successful in providing the term 'diploid' as the word that means 'an organism that has two copies of each gene'.

(b) This natural selection question was the most challenging question on the paper. One aspect of difficulty was that the question described a trend in the frequency of black wolves across a geographical cline, so that an answer featuring a strong selection pressure giving black wolves a selective advantage needed to be anchored in the context of the south where selection operated

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most. Relative survival and reproduction chances then needed to be stated, that black wolves in the population had greater chances of surviving and breeding in the south compared to grey wolves in the population.

Many candidates needed to have a secure grasp of the concept that natural selection acts only on genetic variation within a population, not on immune system changes and immune memory within the lifetime of one wolf. Strong answers identified the selection pressure as the disease CDV and realised that the increased presence of the disease vector (domestic dogs) in the south meant that wolves were more likely to be infected with the disease in the south. While it was true that in these conditions black wolves were more likely to survive infection compared to grey wolves, candidates often made incorrect references to the genetic basis of this. A correct description is that the allele of *CPD103* that gave black coat colour also conferred a degree of resistance to the disease. A common error was to state that black wolves possessed the *CPD103* gene but that grey wolves did not, showing a misunderstanding of what a diploid organism is and what alleles are.

This question proved to be a strong discriminator, with candidates with secure understanding of genetic terms and the ability to use genetic terminology correctly being able to explain the scenario, while weaker candidates often showing no or little understanding of the context or the principles of evolution by natural selection.

(c) There were many ways of describing the relationship shown in **Fig. 4.1**. Some candidates realised that black wolves survived infection and retained antibodies in their blood while grey wolves were more likely to die of the infection and so were not present in the population for their antibody titre to be measured. Most candidates gained credit for stating the relationship, either in a two-part statement or with a precise term like ‘directly proportional’ or ‘positive correlation’. Stating that the relationship was ‘proportional’ alone was insufficient. Weaker candidates struggled to give a clear explanation based in biological facts.

Question 5

(a) Candidates were most confident about the link between ADH and osmoreceptors, and secondly with all three hormones binding to receptors on cell surface membranes. It is essential that the instructions given about placing a tick or a cross in each box are followed, as some candidates left blank boxes and some made the mistake of changing an answer into a ‘hybrid tick’ instead of crossing out their first attempt and writing a new answer. A ‘hybrid tick’ is a tick that is then crossed through, and since it cannot be recognised as either a tick or a cross, it is disregarded, losing the credit available for that answer row.

(b) Strong answers gave paired statements, such as chemical versus electrical signalling, and transport by blood or along neurones. Weaker answers wrote about the endocrine system and then turned their attention to the nervous system, without attempting to select paired differences between them. Well-prepared candidates with good examination technique who could organise their thoughts did well on this question.

(c) (i) Most identified **C** as the length of a sarcomere.

(ii) Many identified **B** as a region where actin and myosin overlap.

(iii) Candidates were asked to describe and explain how **D** changes during muscle contraction. Generally this topic was well known and well understood. Many answers started with the explanation and omitted to state that **D** gets shorter. Some candidates wrote about tropomyosin changing shape rather than physically moving in order to expose the myosin-binding sites on the actin filaments. Some weak answers discussed what happened to the A-band, I-band and H-zone without stating how this affected **D** and without explaining the biochemical events involved.

Question 6

(a) (i) Most answers gave some relevant ideas on how IUCN assessments help to conserve biodiversity and there was widespread confusion between the roles of the IUCN and CITES. The most common correct point was that these assessments raise awareness of endangered species. Candidates also often gave an example of a conservation action that might be taken, though many omitted to state that this happens as a result of the IUCN assessment providing information to governments or other bodies who are in a position to take action to try to protect a species. Strong answers

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explained that the real point of the ranking system of assessment is so that the most endangered species can be known and prioritised for conservation interventions.

(ii) Thoughtful candidates understood the question wording about how the abundance of the butterfly species *Phengaris arion* differs across its distribution. They also followed the question rubric and analysed **Fig. 6.1** and the IUCN assessments and deduced that *P. arion* is more abundant in Asia than in Europe, and that it has a higher risk of extinction in Europe. Weaker candidates often needed to answer the question as written and instead gave reasons as to why the abundance of the butterfly differs across its distribution. For this reason nil-scoring answers featuring selection pressures like predators and competition, being less adapted, and ideas like the butterflies being hunted or 'captured for live pets' were not uncommon.

(b) (i) This question required candidates to use the information given and select from their knowledge the relevant factor acting in the particular scenario described, which was that habitat loss drove extinction. Good answers also gave a sensible suggestion for why the habitat had been reduced in area or lost, such as changes to farming practices or urban development. Some also linked the mention of flowers in the information given to the adult butterfly's need for nectar as food. Some candidates instead gave a generic list of reasons why species of any kind anywhere may go extinct, drawing on Learning outcome 1 from Section 18.3 of the syllabus.

(ii) The advantages of restoring entire habitats are subtly different from the reasons why we conserve a given species. Some candidates wrote excellent answers, focusing on the ability of a restored habitat to support increased biodiversity, the maintenance or restoration of food webs, the aesthetic benefits of a restored habitat, the potential restoration offers for ecological research and the potential for ecotourism. Our moral obligation to prevent the extinction of species was also mentioned by some candidates. Weak answers focused on a single species or captive-bred individuals rather than a whole ecological community; such answers were too narrow in focus and tended to be vague, e.g. so animals can find food, feel safe, find mates and avoid disturbance.

Question 7

(a) The most common correct feature of ATP in this context was the role of ATP in releasing energy, though some lost credit by using a verb such as 'making' or 'producing', instead of giving or releasing for the conversion of energy from one form to another. The products of hydrolysis of ATP were stated in some answers, and many knew the molecule had a high turnover; there were a few candidates who needed to understand that this means it can be used and then regenerated. Many answers stated that ATP is small or soluble and related this to ease of transport, and some correctly stated that this transport occurs within a cell. Others did not specify this or made the mistake of suggesting that ATP moves around the body in blood. Few answers covered at least three relevant points to achieve full credit.

(b) Many candidates answered this question on how rotenone reduces the production of ATP and water in aerobic respiration well. Underlying knowledge of the steps in oxidative phosphorylation was good, and most candidates remembered to state that each step will happen less or not at all due to the impact of rotenone in preventing electrons from passing from the first carrier in the electron transport chain. Candidates who stated 'less' of each stage sometimes noted that reduced FAD would continue to pass electrons to the second carrier. The reduction in ATP yield was well explained, with the main omissions being answers that described proton movements without stating the mechanisms by which they move in each direction (pumped to intermembrane space, diffuse back through ATP synthase). Explanations for the reduction in production of water were often incomplete; candidates needed to explain that the reason why oxygen will accept fewer electrons is because fewer electrons reach the fourth carrier in the chain where this reaction occurs. Some candidates realised that the stopping of electrons at the first carrier would mean reduced NAD not being able to offload hydrogen to regenerate the oxidised form of NAD and that this would stop or reduce the processes that rely on the coenzyme NAD for dehydrogenation reactions, i.e. glycolysis, the link reaction and the Krebs cycle.

Question 8

(a) Candidates used the information in **Table 8.1** to explain how the GM soybean might help to solve the global demand for food. Most candidates stated that the modification would enable the GM soybean to have a higher yield. Some explained that this was because the modification gave the soybean plant resistance to herbicide. The most thoughtful or knowledgeable candidates

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elaborated on this, explaining that a herbicide is used to kill weeds to reduce competition between the crop plant and weed for resources such as light or soil nutrients. Many candidates needed to know the purpose of a herbicide, suggesting it killed insects or pests, for example.

(b) (i) Most named the enzyme that would cut out a gene as a restriction enzyme or restriction endonuclease.

(ii) Most named an enzyme that would join a gene to a plasmid as DNA ligase.

(c) This was a suggest question that proved challenging to some candidates. Strong answers explained why some countries do not grow this GM soybean due to unsuitable climate, a ban on GM crops, a lack of land for crop-growing and a societal bias against GM technology. Many candidates were vague about the idea of some countries being unsuitable for growing soybeans by referring just to the 'environment' or 'conditions' being wrong, rather than specifying a factor such as unsuitable climate or soil.

Question 9

(a) Most candidates succeeded in naming one of the two labelled regions of the kidney.

(b) Most candidates could give some relevant information about the mode of action of a biosensor, and the mark scheme accommodated those who had been taught about later generation designs as well as the system involving both glucose oxidase and peroxidase described on the syllabus.

Weaker candidates struggled particularly by not reading the question properly. The question stated, 'Outline how a biosensor measures the concentration of glucose in urine.' While biosensors can measure the concentration of glucose in both blood and urine and might be used more frequently in practice to test blood, this question was about urine. Those who wrote about blood had made a fundamental mistake and missed out on credit.

Question 10

Candidates were asked to explain the relationship between genes, proteins and phenotype with reference to two examples of genetic diseases in humans.

Albinism was the most common choice and the one which candidates described most successfully, with many being able to name the gene and the enzyme it codes for, and to explain the biochemical and physical or physiological effects. Few noted that albinism is a recessive condition, or stated that two copies of the mutant allele are needed for the albino phenotype to show. Occasional mistakes included suggesting *TYR* codes directly for melanin, or for the amino acid tyrosine. Another error was to describe the albino person as having 'red eyes' or 'red pupils' instead of very lightly pigmented or transparent irises that may appear red or pink.

Descriptions of Huntington's Disease often named the gene and not the protein. Answers frequently referred to the additional CAG repeats and sometimes to symptoms.

Descriptions of haemophilia were usually good. The correct protein was named more often than the gene *F8*. The problem of blood not clotting or the risk of excessive bleeding after injury was well known, as was the X-linked or recessive nature of the haemophilia allele. Few answers gave molecular level detail about the role of factor VIII in allowing the conversion of fibrinogen to fibrin. Occasionally, candidates confused haemophilia with sickle cell anaemia.

Knowledge of the causative links between the gene, protein and phenotype was poor for sickle cell anaemia. Some named *HBB* and stated that it coded for the β-globin chains of haemoglobin. A few responses explained that the abnormal haemoglobin molecules form rods that disrupt the shape of the red blood cells they are contained in. Weak answers suggested haemoglobin blocking blood vessels, or a gene coding for an entire red blood cell. Some candidates also thought sickle cell anaemia was recessive rather than codominant.

Other genetic diseases that featured in a small number of answers were cystic fibrosis and hereditary breast cancer.

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Key messages

Strong candidates were able to convey their knowledge in clearly-worded, punctuated sentences. They focused on the meaning of the question and tailored their answers to the specific context presented.

A significant minority of candidates struggled to express their meaning in clear, intelligible English. Accounts where there were no full stops to mark the end of sentences (separate ideas) and no capital letters to mark the start of a new sentence or idea had limited ability to communicate a logical sequence or argument clearly.

General comments

Some candidates were well prepared in terms of having revised the subject matter, while others listed relevant and irrelevant remembered facts and needed to pay greater attention to the way the question was framed and to providing a logical answer. Students who could remember facts and select only the relevant ones and then link these in a clear and logical way met the AO1 and AO2 requirements of the exam successfully.

The best-known topics were respiration, photosynthesis, dihybrid cross genetics and cell signalling. Exam technique let some candidates down on **Question 2(a)**, **Question 8(a)** and **Question 10(a)**. **Question 4** challenged many candidates to think more carefully about what they understood by selection versus genetic drift and how they used the term ‘allele frequency’.

Comments on specific questions

Question 1

(a) Candidates identified features associated with a sensory neurone. The main difficulty seen was the meaning of the word dendron as many candidates wrote both **C** and **E** for an area where dendron membrane depolarisation occurs. **C** and **E** both showed nodes of Ranvier, but **E** was on the axon on the side of the cell body that leads towards the synaptic knobs.

(b) Candidates interpreted a diagram of a presynaptic membrane that showed the action of an opioid receptor. Weaker candidates wrote about the normal occurrences at the synapse without explaining how the presence of an opioid drug would alter these. Strong answers named the neurotransmitter that features in a cholinergic synapse and were specific about naming neurones and membranes as presynaptic and postsynaptic. Some candidates made the error of stating that ions diffuse into a membrane rather than into the cytoplasm of a cell.

Question 2

(a) Some stronger candidates completed the task successfully. More than one correct answer was required for three of the features, for example, three stages in the diagram showed haploid cells; many candidates named only one of these. Many answers needed to list in full the stages of meiosis corresponding to each feature.

(b) Answers focused on the need to prevent self-pollination or self-fertilisation. Some candidates could not describe this adequately and used inappropriate terms like avoiding ‘self-mating’ and ‘asexual

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reproduction'. Strong answers showed awareness of the need to have pollen coming from a different parent plant.

(c) Most answers to this question on the syllabus learning outcome 'Inbreeding and hybridisation to produce vigorous, uniform varieties of maize' were muddled and needed to distinguish between the inbreeding and strong artificial selection stage that occurs over several generations and the subsequent hybridisation event. Candidates rarely identified a phenotypic character that selective breeding would aim to improve or establish in an original inbred line, and very rarely realised hybridisation would occur with a separate variety showing a different desirable trait.

Question 3

(a) Some candidates were able to name the enzymes and steps used in genetically engineering herbicide-resistant soybean and named the regulatory DNA introduced as a promoter to ensure expression of the introduced bacterial gene. Weaker answers generally named appropriate enzymes like restriction endonuclease and DNA ligase and needed to go on to mention using a vector to combine the new gene and the regulatory DNA into a DNA package that could be introduced into a host cell.

(b) The total area used to grow GM crops worldwide was 180.31 million hectares. Some candidates gave a final answer that was out by 10^6 as they omitted to state million. Some candidates rounded the answer inappropriately. An error of logic led to some candidates dividing the 90.155 million hectares of soybeans by two, instead of multiplying it by two to go from 50% of the world crop area to 100% of the world crop area.

(c) A balanced answer about the social implications of growing GM crops should include both positive and negative implications. Candidates mentioned higher yields, lower food prices for consumers, lower pesticide use and improved nutritional quality of crops such as Golden Rice as positives. Negatives included the evolution of resistance to over-used herbicides, contamination of organic crops with self-seeded GM plants, possible food allergies, increased herbicide residues on produce and consumer mistrust. Good answers reflected an up-to-date appreciation, whereas weaker answers gave concerns from the 1990s which have not become a serious problem, e.g. direct transmission of genes from GM crops to wild relatives to create 'superweeds'.

Question 4

(a) (i) **Fig. 4.1** showed the relative frequency of the **T** (dominant) allele in a population. Candidates were asked to use the graph to state the relative frequency of the **t** (recessive) allele after 20 generations. Some understood the information given that the relative frequencies of the two alleles of a gene add up to 1 and calculated the frequency of **t** as 1 – 0.7 = 0.3, but many simply read the frequency of **T** off the graph.

(ii) Possible explanations for the change in the relative frequency of the **T** allele could involve genetic drift creating fluctuations due to chance, or alternatively could involve directional selection where the selection pressure changed after generation 7 to give the early decrease and subsequent increase of **T**. Most candidates struggled to give one coherent explanation, and many answers confused genetic drift, which occurs solely due to random chance events, with natural selection, where relative survival is influenced by how the genotype equips an organism against prevailing selection pressures.

(b) **Fig. 4.2** showed an alternative scenario with the obvious difference that the population was smaller (10 individuals instead of 50 in **Fig. 4.1**). Many candidates noted this and explained that the early extinction of the **T** allele from the gene pool was due to this small population size, i.e. a bottleneck effect. Strong answers showed understanding by stating that the effect of genetic drift is greater in a small population, or that chance events have a more dramatic effect in a small sample size.

(c) Some candidates were able to recall and spell the term Hardy-Weinberg. Many others gave vaguely similar names, and some gave other terms entirely like 't-test' and 'Simpson's index'.

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Question 5

(a) Strong candidates used the information given to reason why fruit flies are still used in genetic crosses, for example, the ability to produce many offspring in a short time giving results quickly. Weaker candidates repeated the question information without deriving any new insights from it.

(b) Many candidates showed the working out of the genetic cross in detail, showing how they deduced offspring phenotypes from the genotypes in the Punnett square. The most common errors were not giving an adequate key to the symbols chosen and not linking phenotypes to genotypes, for example by colour-coding the boxes of the Punnett square or by using symbols or the initials of the phenotypes in the boxes.

(c) Many answers described a test cross with an individual homozygous recessive at both loci, and most of these were able to explain what the possible results would mean about the genotype of the F2 parent.

Question 6

(a) (i) Some candidates were able to select words to adequately describe the rise and fall in blood glucose concentration of the person without type 2 diabetes. Many other descriptions were imprecise or incorrect. For example, the increase occurred during or over the first 30 minutes, not 'at 30 minutes'. The original blood glucose concentration was recovered within 90 minutes of drinking, not 120 minutes. When describing relationships shown on graphs, candidates should quote the relevant axis labels where necessary, e.g. the changes occurred in the blood glucose concentration (y-axis label), not in 'the curve'.

(ii) Candidates were usually successful at calculating the percentage increase in blood glucose concentration for the person with type 2 diabetes between 0 and 60 minutes, obtaining an answer of 83.3%.

(iii) Candidates made various correct suggestions, including injecting insulin and reducing carbohydrate intake in the diet.

(b) Descriptions of the cell signalling pathway involving glucagon were mostly detailed and accurate. Some answers omitted to state that the glucagon receptor is on the cell surface membrane of liver cells. Occasionally, candidates confused glycogenolysis with gluconeogenesis, or made spelling errors that negated what they were trying to explain due to the impossibility of distinguishing between incorrect spellings of glucagon and glycogen.

Question 7

(a) Well-prepared candidates had no difficulty in supplying the missing terms phylum, order and *Strigops* in the table. Many other answers were incomplete or wrong.

(b) Answers to this suggest question were sensible, and most candidates could make at least one relevant suggestion rooted in the question context of the ecology of the kakapo, such as excluding humans and predators, and ensuring that the habitat provided enough food.

(c) Many candidates referred to a decrease in genetic variation and a lower ability to adapt to future change. Inbreeding depression featured in some answers. Vague references to an 'increase' in harmful recessive alleles did not gain credit unless linked to the idea of these being more likely to be expressed due to coming together in a homozygous genotype more often in a small population.

Question 8

(a) Candidates were asked to identify **X** within their answer from **Fig. 8.1**. A significant proportion needed to clearly state which of the molecules and ions under discussion might be **X**. A few answers identified calcium ions as a second messenger and many knew that ABA binding caused the water potential of guard cells to increase, resulting in loss of water by osmosis and the guard cells becoming flaccid. A few weaker candidates made the mistake of referring to stomata instead of guard cells.

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(b) The strongest answers covered the diurnal pattern of stomatal opening and closure, and also at least one reason for opening and one for closing, plus a further environmental condition that causes stomata to close. Weaker answers were more limited; some mentioned the cooling effect of transpiration, and some explained the importance of water homeostasis to plants in terms of maintaining turgidity of cells or the importance of water as a medium for chemical reactions in cytoplasm.

Question 9

(a) Errors in naming the two coenzymes involved in the link reaction were writing 'reduced NAD' instead of NAD, and abbreviating coenzyme A to 'coA'.

(b) Candidates described the effect of hydrogen peroxide concentration on the activity of the Krebs cycle enzyme with varying degrees of precision. Most answers successfully compared figures taken from the graph for both concentrations at 10 minutes, quoting the concentration units in full and giving the enzyme activity as a percentage.

(c) Answers were generally very good, with the successive stages involving hydrogen ion movements and chemiosmosis being carefully described. The mechanism of transport of the hydrogen ions in both directions was expected, and some answers needed to state that this is by pumping (using the energy from the electron transport chain) from the matrix to the intermembrane space, and by (facilitated) diffusion in the reverse direction through ATP synthase. A few candidates miswrote ATP synthase as 'ATPase'. Some answers repeated steps 1 and 2, which had been written out for them, in their answer, which used up valuable exam time.

(d) Many answers gave suggestions rooted in secure syllabus knowledge, referring to anaerobic conditions developing in the muscles of the person doing the fast-running exercise and the production of lactate as a result. Incorrect statements were sometimes made about lactate 'breaking down' to pyruvate (both are 3-carbon molecules) and this requiring oxygen. The need for oxygen in repaying the oxygen debt is indirect, with it being needed for additional oxidative phosphorylation to generate extra ATP to power energetically unfavourable reactions such as the conversion of lactate to glucose.

Question 10

(a) Strong answers showed good exam technique in referring to both cyclic and non-cyclic photophosphorylation in order to establish a difference for each point that was being made. Weaker answers gave statements about one, for example that non-cyclic involves photolysis, without drawing the distinction that cyclic does not involve photolysis. Pairs of statements are needed to list differences. Answers set out in a table often scored well.

(b) Candidates supplied the missing words in a cloze passage about the Calvin cycle. Candidates generally named carbon dioxide and rubisco but for 'reduced NADP' sometimes wrote just NADP or reduced NAD instead. There were a range of acceptable answers for the last blank, including hexose, carbohydrate was too vague as the Calvin cycle is based on other carbohydrate intermediates.

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Paper 9700/51
Planning, Analysis and Evaluation

There were too few candidates for a meaningful report to be produced.

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Paper 9700/52
Planning, Analysis and Evaluation

Key messages

Candidates should read the whole question carefully prior to answering.

Certain themes appear commonly, including planning an investigation and statistical analysis of data. Those candidates who have practised these skills are more likely to do well.

When planning an investigation, it is important to set out the work in a logical way and for it to be detailed enough to let another person follow it.

General comments

For **Question 1(a)(iii)**, many candidates stated that the time in which the lower epidermis was left in the sucrose solution on the slide would be standardised before measuring the width of the stomata. Some candidates suggested an actual time to be used and were only awarded credit if this was clearly the same for each.

The word 'average' should not be used in place of the term 'mean' in scientific work.

It is important that candidates read the instructions carefully to determine what they need to include in their answers, in **Question 1(a)(iii)**, how to prepare the slides was not required.

Candidates should be aware that where the question asks for a certain number of responses, such as in **Question 3(a)**, the list rule is applicable. Any incorrect answer could reduce the credit awarded.

Comments on specific questions

Question 1

(a) (i) Many candidates correctly identified the independent variable as the concentration of sucrose solution, with a relatively small minority not including the term concentration. Identifying the dependent variable as the width of the stomata was achieved by the vast majority of candidates.

(ii) This question required candidates to determine the correct volumes of sucrose solution and distilled water needed to prepare two different concentrations of sucrose solution. The majority of candidates were able to correctly calculate this, with only a small number not ensuring that their total volume came to 20 cm^3.

(iii) There were some clear and detailed plans which gained full credit. Some of the less creditworthy responses just copied out the basic procedure provided in the question. There were a number of candidates who spent time repeating how to prepare the slides which did not gain credit and used up valuable exam time.

The vast majority of candidates were able to outline that they would measure the width of the stomata in all stated sucrose concentrations.

Many candidates were able to state that the time in which the lower epidermis was left in the sucrose solution on the slide would be standardised before measuring the width of the stomata.

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Some candidates suggested an actual time to be used. Those candidates who referred to leaving it about 30 minutes did not gain credit. It needed to be clear that the time was the same in each case. The most successful answers detailed that the eyepiece graticule would need calibrating and that the width of the stomata should be measured at its widest point.

Many candidates referred to the use of a water bath and buffer in their answers which were not relevant for this investigation.

Some responses clearly stated they would measure the width of at least three separate stomata for each concentration, whilst others suggested that they would repeat the experiment three times. This latter answer did not gain credit as it was not clear if the width of the same stomata would be measured three times, rather than the width of three separate stomata.

A number of candidates were able to suggest that a mean would need to be calculated for each separate sucrose concentration. Some did not gain the credit as they referred to calculating an average. There were a number of candidates who were not clear that they would calculate a mean for each sucrose concentration. Answers stating that they would repeat the whole experiment three times and calculate a mean, therefore, did not gain credit.

Safety issues should be specific to the investigation. Many candidates gained credit for correctly identifying a hazard, risk and a suitable precaution. Some candidates incorrectly identified the sucrose solution as being a hazard, rather than the plant material. A few candidates just referred to being careful when handling the plant material, slides or scalpel and this was insufficient to gain credit.

(iv) Candidates who predicted that the width of the stomata would decrease if the sucrose concentration increased gained credit. There were some clear explanations as to why the stomatal width decreased, with successful responses including that water would leave the guard cells by osmosis. Some candidates made reference to water leaving the stomata, or stated that it was sucrose solution, rather than water, which was moving. These answers did not gain credit.

Those candidates who incorrectly stated that the stomatal width increased, were able to gain credit if they correctly explained how this would have occurred, referencing that water would have had to enter the guard cells by osmosis for this to happen.

(b) (i) Candidates were asked to calculate the stomatal density on the lower epidermis using **Fig. 1.3**. Some candidates attempted to calculate the area of the stomatal aperture instead. Credit was given to many who identified that there were 13 stomata in the field of view and who were able to accurately measure either the diameter of the field of view or the length of the scale bar. Some candidates needed to include units here to attain the credit. Fewer candidates were able to use these measurements to calculate the actual area of the field of view and then use this to correctly calculate the stomatal density. Those candidates who were able to calculate the magnification from the scale bar gained credit. The more successful answers were from candidates who laid out their working clearly, allowing them to work through their calculations in a logical manner to ensure that they did not miss a crucial step in their calculation. These responses gave the answer of 367. Some candidates attempted to calculate the area of the stomatal aperture instead of the stomatal density.

(ii) Many candidates were able to suggest how the investigation could be improved by stating a variety of different ways in which this could be done, such as using more than one leaf, epidermal peel or field of view or by investigating more sections from the same epidermis or leaf. Credit was not awarded for answers which referred to simply repeating the investigation three times.

(iii) The most successful answers were succinct, with candidates naming just one or two environmental conditions and explaining that these resulted in less water being lost or reduced transpiration. There were some candidates who listed many environmental conditions, some of which were incorrect, which resulted in them contradicting themselves and therefore, not gaining credit.

Some candidates misinterpreted what this question was asking them, and rather than suggesting how the environmental conditions of a different plant species resulted in a lower stomatal density compared to the plantain lily, they discussed what conditions may have led to the width of the stomata decreasing. Candidates should ensure that they read all of the information provided in the question carefully before answering.

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Question 2

(a) Many candidates were able to correctly calculate the percentage decrease in transpiration rate and showed their working, gaining full credit for 27%. A few candidates picked the incorrect bars from **Fig. 2.1**, and some used the incorrect value as their denominator.

(b) Some candidates were able to identify the trend from **Fig. 2.1** that as ABA concentration increased, the transpiration rate decreased, with the exception of the ABA concentration of 50 μmol dm^{-3}. Candidates who identified which standard error ranges overlapped and explained that this meant that there was no significant difference in transpiration rates gained credit. As the question asked for evidence from **Fig. 2.1** to support the conclusion, specific ABA concentrations needed to be referenced. A few responses also gained credit for correctly identifying which standard error ranges did not overlap and went on to suggest that this meant there may be a significant difference in transpiration rates.

(c) This question asked what additional information was required to increase the confidence in the conclusion. The most common response was to carry out some form of statistical analysis on the data collected. Other successful responses included collecting data for the non-mutant variety of thale cress.

As the question asked for information which would increase the confidence in the conclusion, candidates needed to be precise when stating that they would need to know if a named variable had been standardised. Answers suggesting that knowing the investigation had been carried out at the same temperature, or same light intensity, or using the same age of thale cress gained credit. Therefore, answers which just made reference to knowing what the temperature was, did not gain credit, as the temperature may have been different for each experiment, and this information would not have increased the confidence in the conclusion.

Question 3

(a) Candidates were asked to state two variables the student would need to standardise for the investigation using the apparatus shown in **Fig. 3.2**. Candidates needed to state only two variables, rather than list many, as those who did this often included the independent variable or the size of the beaker, which they had already been told had been standardised. The most common responses were to standardise the temperature, light intensity or time the seeds were left in the different humidities.

(b) This question was successfully answered with many candidates being able to state how they would produce different levels of humidity using the apparatus in **Fig. 3.2**. Candidates needed to use the term volume, rather than amount, to gain credit here. Some candidates also discussed the need for a control and suggested leaving one trial with no water added to the filter paper. A small number of answers needed to include what dependent variable would be measured and simply stated that they would look at the appearance of the awn. A variety of measurements were valid, with candidates suggesting they would measure the height of the awn, count the number of coils in the awn or measure the angle in which the awn was pointing. The vast majority of candidates stated that they would repeat the investigation and gained credit.

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Key messages

Careful reading of each question before starting to write is important.

When planning an investigation, it is necessary to make sure of the investigation being asked and to set out the work in a logical way.

Candidates should be given opportunities to practise a variety of mathematical calculations and statistical analysis.

General comments

In **Question 1(c)(ii)**, candidates were asked to describe a method for the investigation that is detailed enough for another person to follow. It is important that candidates provide specific information about how to carry out investigations such as this to avoid credit being lost.

In **Question 1(d)(ii)**, candidates often demonstrated a good ability to analyse statistical data, in this case conclusions from the results of a *t*-test.

In **Question 2(b)(i)**, many candidates were unable to recognise the different types of data presented in the graph of the results of the investigation and would benefit from familiarisation with the information given on page 61 of the syllabus.

Providing candidates with opportunities to practise key mathematical skills is important, as in **Question 2(b)(ii)**, where several candidates were unsure of the method required to calculate the percentage difference.

Comments on specific questions

Question 1

(a) Several candidates correctly identified the independent variable as the presence and absence of juglone, or as the concentration of juglone. Some candidates lost out on credit by only stating the 'presence of juglone' as the independent variable. This omits the control treatment and so did not gain credit.

(b) (i) Candidates often correctly identified that 5 cm^3 of the juglone solution should be used for the dilution. Candidates who used the calculation $C_1V_1 = C_2V_2$ often gave 5 cm^3 as their answer but omitted to state which liquid (juglone) they were referring to. A common error was then to dissolve the juglone in 495 cm^3 of distilled water. In this example, the diluent should be the mixture of solvents that the student was provided with.

(ii) Most candidates who were able to secure credit for this question did so by suggesting that a syringe or a burette should be used to measure the solutions. References to using a pipette did not gain credit, as some types of pipettes (e.g. a dropping pipette) would not allow precise measurements to be taken. The use of a graduated pipette or a micropipette was creditworthy. Candidates should assume that the student carried out their dilution with measuring cylinders accurately; therefore, references to stirring the solutions or reading the meniscus at eye-level were

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not given credit. Suggesting that the student could use larger volumes of both the juglone and solvent mixture to make the solution would reduce the percentage error.

(c) (i) Well-prepared candidates correctly stated the control as replacing the juglone solution with the mixture of solvents. Ideas relating to the control of variables such as light intensity or carbon dioxide concentration were not creditworthy. The best responses explained that the control would allow the student to observe the effect of juglone on the germination and growth of the cucumber seeds. Simply stating that the control would allow comparisons to be made between seeds grown with juglone and seeds grown with no juglone was not sufficient to gain credit.

(ii) This question was reasonably well answered, and several candidates were able to outline a suitable method to investigate the effect of juglone on the percentage of cucumber seeds that germinate and on their growth after germination. A few candidates were able to gain full credit for this question.

Candidates first needed to consider how they would apply the juglone solution to the cucumber seeds in a standardised way. The most common acceptable method was to add a set volume of the juglone solution to the tray of soil. Very few candidates noted that the juglone solution should be reapplied to the seeds on a regular basis. Most candidates attempted to standardise the variables in the investigation, but a lack of precision led to marking points not being achieved. The strongest responses kept the temperature constant by using an incubator or a temperature-controlled room/glasshouse. A water bath would not be appropriate for this investigation. This investigation measures the growth of cucumber seedlings after germination; therefore, carrying out the investigation in the dark is not appropriate. A lamp should be placed at a fixed distance from the seedlings to maintain a constant light intensity. The same variety or age of cucumber seeds should be used, and the same volume of water should be added each day. Credit was also given for using the same type or pH of soil and for planting the seeds at the same depth in the soil.

The majority of candidates considered how they would measure the two dependent variables, although some candidates only addressed either germination or the growth of the cucumber seedlings. Candidates should count the number of seeds that were planted and count the number of seeds that germinated after a set number of days. Measuring the time taken for germination or counting seeds every day with no endpoint for when the percentage germination should be calculated was not creditworthy. Several candidates gained credit by using a ruler to measure the shoot height of each seedling 10 days after the appearance of the seedling above the soil. Many candidates described repeating the experiment; to gain credit further information was required. At least 10 seeds should be used for the tray given juglone solution and for the control treatment. Then, the mean shoot height should be calculated for each group.

Most responses incorporated some form of risk assessment, although stating that this investigation was 'low / medium risk' did not gain credit. Candidates should identify the hazard, state the risk associated with that hazard and clearly indicate the precaution that should be taken. For example, juglone is toxic, therefore gloves should be worn.

(d) (i) Candidates were asked to give two reasons why the *t*-test is an appropriate statistical test to use in the investigation. Many responses correctly noted that the data is continuous and normally distributed. The idea that a *t*-test could be used to compare the means was stated by several candidates. A few candidates knew that the *t*-test was used to compare two groups but without the use of the term 'mean', could not gain credit. No credit was given for stating that each group contained 10 seeds, as candidates had already been told that the *t*-test was appropriate for the number of seeds that were used.

(ii) Many candidates correctly identified the critical value from **Table 1.1** as 2.101 (18 degrees of freedom and $p = 0.05$). They then noted that the calculated *t*-value is less than the critical value. The strongest candidates were well prepared and gained full credit by stating that the null hypothesis should be accepted and that there is no significant difference. A few candidates missed out by omitting 'significant' and just stating that there is no difference. Those candidates who suggested an incorrect critical value were able to gain limited credit by using this critical value to make correct statistical conclusions.

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Question 2

(a) Candidates were asked to state two variables that the scientists should standardise in the investigation. Responses that considered standardising temperature, pH or time were ignored as these variables had already been standardised. The number of bacteria, the volume of the nitrite ion solution and the volume of the nutrient broth were often correctly identified. Candidates should not use the word 'amount' in place of volume in their answers. The concentration of the nitrite ion solution should not be standardised, as this is the independent variable.

(b) (i) Candidates were asked to identify the type of data represented by the species of bacterium and the lowest nitrite concentration. This question confused many candidates so that only the strongest responses identified the species of bacterium as nominal data. More candidates correctly identified the lowest nitrite concentration as continuous data.

(ii) The majority of candidates were able to correctly obtain the values of 0.7 and 5.0 from **Fig. 2.1** and then use these values to calculate the percentage difference between the results for the two species of *Salmonella*. Credit was given for percentage differences of either 86% or 614%; the value obtained is dependent on which species of *Salmonella* is taken as the starting point for the comparison. A few candidates lost credit by inappropriately rounding 614% to only two significant figures.

(iii) Most candidates used **Fig. 2.1** to correctly state the species of bacterium that were most and least affected by nitrite ions. Some candidates identified the correct species and needed to identify which was most affected and which was least affected. When asked to name a species, the full binomial species name should be given.

(c) Most candidates suggested reasons why the student's conclusion might not be valid. Candidates who discussed the effect of nitrites on the various species of bacteria could not achieve credit as they were giving conclusions rather than evaluating the student's conclusion.

Good responses highlighted how nitrites were not tested on people, and the investigation was only carried out on five species of pathogenic bacteria. The potential for nitrites to cause harmful side effects in people was often noted. Candidates frequently stated that nitrites might affect beneficial bacteria in the digestive system; credit was awarded if it was clear that the beneficial bacteria were killed or negatively affected by nitrites. Fewer candidates noted that the investigation was only carried out for 24 hours or that the pH used (pH 4.8) was not representative of the pH of the human digestive system.

Stating that the sample size was small or that there were no repeats did not gain credit; there were 96 wells containing bacterial suspension in each microwell plate. The lack of statistical analysis such as standard error or a *t*-test was awarded credit. The use of a control experiment was rarely suggested. Excellent responses noted that the investigation only measured when no bacterial population growth occurred and that this might not mean that the pathogenic bacteria had been killed.

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Key messages

Careful reading of each question before starting to write is important.

When planning an investigation, it is necessary to set out the work in a logical way and address the specific task that has been set.

Candidates should be given opportunities to analyse a variety of statistical data.

General comments

In **Question 1(a)**, those candidates who were familiar with dilution calculations were easily able to give correct volumes in **Table 1.1**. For **Question 1(b)**, candidates were asked to give a method that is set out in a logical order and detailed enough to allow another person to follow. It is important that all of the details of how steps should be carried out are included.

The term 'average' should not be used in a scientific context where the calculation of a mean is referenced.

Question 3(a)(ii) confused many candidates who were not familiar with the information given on page 61 of the syllabus where candidates are required to recognise the different types of variable and the different types of data presented from data provided. Candidates would benefit from practising this skill.

Comments on specific questions

Question 1

(a) The most common concentrations of sucrose solution suggested were 1.6, 1.2, 0.8 and 0.4 mol dm^{-3}, although other values were also accepted.

(b) This question was well answered, and most candidates were able to describe a suitable method to determine the concentration of sucrose solution that has the same water potential as the cells of the beetroot. Candidates were expected to use the sucrose solutions prepared in **Question 1(a)**, placing blocks of beetroot into each sucrose solution. Credit was given to those candidates who placed beetroot blocks in beakers (or other suitable containers) and ensured that the blocks were submerged in each sucrose solution.

Many candidates considered the variables that would need to be standardised in this investigation, such as the variety of beetroot and the dimensions of the beetroot block. Turnips were identified as *Beta vulgaris vulgaris* on page 2, therefore standardising the species of beetroot did not gain credit. All beetroot blocks should have the same dimensions; blocks with the same volume might have a different surface area. The term 'size' should not be used. Some candidates gained further credit by noting that the outer skin of the beetroot should be removed before making the blocks. Candidates should specify the apparatus to be used: for example, a knife and a ruler would be required to cut beetroot blocks with the same dimensions.

The majority of candidates considered how they would measure the dependent variable, although using a microscope or a colorimeter would not be appropriate for this task. Candidates should measure the initial mass of the beetroot block and then measure the final mass of the beetroot block after a set time interval. Leaving the turnip blocks for less than 10 minutes would not give

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sufficient time for osmosis to take place. The strongest responses included details of how to dry the turnip blocks, for example with a paper towel, before measuring their final mass. Most candidates recognised the need for replicates in the investigation and linked these to the calculation of a mean. Credit was only given to those candidates who used a minimum of three beetroot blocks and calculated a mean for each sucrose concentration.

Most candidates were able to identify a relevant hazard, state the risk that this might pose to the person carrying out the investigation, and indicate the precaution that should be taken. For example, the beetroot might cause an allergic reaction and gloves should be worn. When using a knife, a suitable precaution to prevent a cut to the skin is to cut away from your hand; most gloves that are used for PPE would not prevent this.

(c) (i) Candidates were asked to complete the sketch graph, including labelled axes, to show the results that the candidate obtained. Most responses included correctly labelled axes with a decreasing line that crossed the *x*-axis. Some candidates needed to include units for sucrose concentration.

(ii) This question was well answered, with most candidates understanding that the x-axis intercept where the percentage change in mass is zero indicates the sucrose concentration with the same water potential as the cells of the beetroot.

(iii) Several candidates suggested rinsing the beetroot blocks with distilled water or drying the blocks with tissue paper. These improvements gained credit as they would reduce the amount of red pigment in the sucrose solutions.

Question 2

(a) To be successful, candidates needed to understand that a method was required to measure the image length of the curved claw. The use of a microscope or magnification calculations were therefore not required. Some candidates achieved the credit by using a string to find the length of the claw and then using a ruler to measure the length of the straightened string.

(b) (i) Candidates were asked to state one other variable that should be standardised when making the discs for the artificial flower apparatus. Creditworthy responses included standardising the colour or material of the disc. References to the drop of sucrose solution or to the support did not gain credit as these are not part of the actual disc.

(ii) Most candidates correctly identified the independent variable as the level of roughness or the mean particle diameter.

(iii) Many candidates were able to use the data provided to calculate the number of feeding visits when buff-tailed bumblebees hovered. Credit was given for answers of either 24 or 25; after allowance for rounding, both values could be valid. A few candidates lost credit by giving the number of feeding visits when the buff-tailed bumblebees gripped on to the disc, or by not giving their answer to the nearest whole number.

(iv) Several candidates gained credit by correctly describing the trend: as the particle diameter increased, the percentage of feeding visits when buff-tailed bumblebees gripped on to the disc also increased. References to percentage of feeding visits that were not linked to gripping did not gain credit. Further credit was given to those candidates who noticed that at 30 μm and 53 μm, there was no change in the percentage of feeding visits when buff-tailed bumblebees gripped on to the disc. Some candidates noted that no buff-tailed bumblebees gripped on to the disc at 5 μm; this was not sufficient to gain credit. A very few candidates realised that this indicated that all the bumblebees were hovering to feed from the artificial flower at 5 μm.

(c) (i) This was a straightforward question for those candidates who were familiar with statistical analysis involving Spearman's rank correlation. These candidates gained full credit by completing **Table 2.2** correctly and stating ΣD^2 as 0.5. Several candidates needed to recognise that the last two tied ranks should both be given an average rank of 5.5; they often incorrectly calculated ΣD^2 as 1.

(ii) Many candidates were able to use the formula for Spearman's rank correlation to correctly calculate r_s as 0.99. Candidates who had missed out in **Question 2(c)(i)** were able to secure full credit for **Question 2c(ii)** by calculating the correct r_s value for $\Sigma D^2 = 1$.

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(iii) There were many good responses, stating that the null hypothesis should be rejected because the calculated value for r_s is greater than the critical value, 0.83. Some candidates selected the wrong critical value or did not identify 0.83 as the critical value; these candidates did not gain credit.

Question 3

(a) (i) The majority of candidates were able to correctly calculate all the mean values in **Table 3.1**. These values should be rounded to either two or three significant figures. All of the data in **Table 3.1** had two significant figures; the calculated means should have the same, or one more, significant figures than this data.

(ii) Candidates were asked to identify the type of variable and the type of data represented by the type of fruit and the volume of juice extracted. Candidates needed to be familiar with the information given on page 61 of the syllabus. The strongest candidates completed **Table 3.2** correctly to gain full credit. The terms 'independent variable' and 'dependent variable' did not gain credit as these terms were identified in the stem of the question. Several candidates correctly identified the volume of juice extracted as continuous data.

(iii) Several candidates were able to suggest changes that could be made to improve the candidate's method. Standardising the mass of fruit used or standardising the size of each fruit piece were commonly suggested. A few candidates noted that the age or ripeness of each type of fruit should be standardised. A syringe or a burette could be used to accurately measure the volume of pectinase. A burette would also potentially allow the volume of fruit juice to be measured accurately. Very few candidates suggested the use of a control experiment, replacing pectinase with either distilled water or a solution of boiled pectinase.

(b) Candidates were uncertain about what this question was expecting of them. Repeating improvements to the method from **Question 3(a)(iii)** was not appropriate. The candidate's method from **Question 3(a)** could not determine the quantity of pectin in the cell walls of different types of fruit because the volume of juice is not correlated with the quantity of pectin. The strongest responses noted that the age and ripeness of fruit will affect the quantity of juice more than the quantity of pectin. The idea that the cell walls of different fruits have different compositions was rarely seen.

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