BIOLOGY

Paper 9700/11
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Questions 1, 2, 14, 15, 22, 33 and 36

More than half of all candidates answered these questions correctly.

Question 3

Two thirds of the strongest candidates answered this correctly. Weaker candidates found this question particularly challenging.

Questions 4, 6, 18, 21 and 35

Most of the strongest candidates and the largest proportion of the weaker candidates answered these questions correctly.

Question 5

Most of the weaker candidates incorrectly concluded that reducing sugars were present in the original mixture.

Question 7

The majority of the stronger candidates answered correctly, less than a third of the weaker candidates correctly answered this question.

Questions 8, 11, 20, 29 and 39

More than half of the weaker candidates answered these incorrectly.

Question 9

Nearly a quarter of all candidates appreciated that all three properties were valid explanations.

Question 10

Most candidates incorrectly suggested that bond 2 was correct. This bond is only counted as part of the primary structure.

Question 12

Candidates found this challenging. The substrate concentration (3) has not reached zero, so there remains a constant concentration of enzyme-substrate complexes.

Question 13

A third of all candidates correctly interpreted this data.

Questions 17, 19, 25, 26, 27, 28, 31, 32, 34 and 40

Over half of the weaker candidates answered these questions incorrectly.

Question 23

Less than half of all candidates incorrectly suggested that conclusion 1 was correct. Mutations change the order of nucleotides in genes, not the order of amino acids in genes.

Question 24

More than half of all candidates incorrectly selected option **A** or **B** suggesting that they misread the question asking for the tRNA anticodon.

Question 30

Over half of the weaker candidates incorrectly identified the cell as a B-lymphocyte.

Question 37

Less than half of all candidates confused immunity with resistant genes.

Question 38

Over half of all candidates were unaware of the role played by T-lymphocytes outside of the blood.

BIOLOGY

Paper 9700/12
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Questions 1, 8, 38 and 40

Most of the stronger candidates and more than half of the weaker candidates answered these questions correctly.

Question 2

Less than a third of weaker candidates correctly selected option **B**.

Questions 3, 5, 9, 11, 14, 15, 18, 20, 21, 23 and 35

Most of the stronger candidates answered these questions correctly. However, less than half of the weaker candidates answered correctly.

Question 4

Nearly half of all candidates realised that ATP would be needed for the formation of lysosomes and therefore that mitochondria are required.

Questions 6, 10, 12, 24, 26, 28, 29 and 39

Over half of all candidates answered these questions correctly.

Question 7

Less than half of all candidates answered this correctly. A positive Benedict's test only shows the presence of reducing sugars, not a specific named reducing sugar.

Question 13

Less than a half of all candidates answered this correctly with almost a third incorrectly selecting option **D**. Not all protein molecules have a metal ion in the quaternary structure.

Question 16

Less than half of all candidates were able to process the information provided and answer this correctly. When the vesicles fuse with the cell surface membrane, the glucose transport proteins from the vesicle membranes will become incorporated into the cell membrane. This will allow glucose uptake to occur by facilitated diffusion.

Question 17

Candidates found this very difficult. All the agar blocks are stained uniformly. Therefore the original block of 1.0 cm × 1.0 cm × 1.0 cm will contain 1.0 cm^3 of uniformly stained agar.
A block 0.5 cm × 0.5 cm × 0.5 cm will contain 0.125 cm^3 of uniformly stained agar.
A block 0.5 cm × 1.0 cm × 1.0 cm will contain 0.5 cm^3 of uniformly stained agar.
A block 2.0 cm × 1.0 cm × 1.0 cm will contain 2.0 cm^3 of uniformly stained agar.

In the two options at 30°C, the volume of uniformly stained agar is the same as in the original block. Therefore the dye in the water will be at least the same colour as in the original experiment, if not darker blue.

At 20°C in option **B**, there is only a quarter of the volume of uniformly stained agar, so as this diffuses out the water will be a lighter blue colour.

Question 19

Most of the stronger candidates answered this correctly. Almost half of the weaker candidates forgot that at metaphase there would be 52 chromatids, each with a telomere at both ends.

Question 22

Almost half of all candidates incorrectly selected option **A**. 18 is the number of guanine bases in strand 1. The number of guanine bases in the piece of DNA is obtained by adding the total from strand 1 and strand 2.

Question 25

More than half of the weaker candidates incorrectly suggested that statement 3 is correct.

Questions 27, 30 and 31

Whilst most of the stronger candidates answered correctly, the weaker candidates selected each option almost equally for these questions.

Question 32

Less than half of all candidates were able to work out the correct answer.

Question 33

Over half of all candidates were able to correctly describe the image of the gas exchange system.

Question 34

Less than half of all candidates incorrectly selected options containing squamous epithelium. This type of epithelium is present in the alveoli.

Question 36

Whilst most of the stronger candidates and a quarter of weaker candidates knew that tar is a carcinogen.

Question 37

More than half of all candidates were able to identify suitable control measures to reduce the spread of tuberculosis.

BIOLOGY

Paper 9700/13
Multiple Choice

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

* This question has been discounted.

General comments

The paper differentiated well.

Comments on specific questions

Questions 1, 2, 9, 10, 17, 20, 22, 25, 26, 27, 28, 32 and 33

Less than half of the weaker candidates were able to answer correctly, whilst most of the stronger candidates answered correctly.

Question 3

This was well answered by the stronger candidates and more than half of the weaker candidates. Incorrect answers most commonly suggested that a typical prokaryote has a size of 1.5×10^2 nm or less.

Question 4

Just over half of all candidates realised that *Plasmodium is* eukaryotic and would contain all three structures.

Question 5

Less than half of weaker candidates incorrectly indicated that chloroplasts do not contain nucleic acid, whilst over three quarters incorrectly suggested that the Golgi body does contain nucleic acid.

Questions 6, 8, 12, 13, 18, 23 and 39

More than half of all candidates answered these questions correctly.

Question 7

Due to an issue with question 7, this question has been discounted. Candidates' marks have been multiplied by a weighting factor so that the maximum mark for the question paper remains unchanged.

Question 11

Almost half of the weaker candidates incorrectly selected option **B**. β-pleated sheets are not formed by the chain of amino acids coiling.

Question 14

More than half of the weaker candidates incorrectly stated that statement 1 was true for all enzymes.

Question 15

Nearly half of all candidates incorrectly suggested that only statement 3 was correct.

Question 16

Nearly half of the weaker candidates incorrectly stated that Z contained air.

Question 19

Nearly half of all candidates realised that all four processes would need to take place.

Question 21

Almost half of the weaker candidates incorrectly suggested that uracil was a purine.

Question 24

More than half of the weaker candidates incorrectly stated that the walls of sieve tube elements are lignified.

Questions 29 and 36

Most of the stronger candidates answered correctly. Weaker candidates selected each option almost equally.

Question 30

More than half of the weaker candidates were able to correctly identify the types of blood cell.

Question 31

More than half of the weaker candidates incorrectly suggested that carboxyhaemoglobin transports carbon dioxide.

Question 34

Most of all candidates answered this correctly.

Question 35

Over half of all candidates did not suggest statement 3 in their selection.

Question 37

Just over half of all candidates answered this correctly.

Question 38

Over three quarters of the stronger candidates and less than quarter of the weaker candidates answered correctly.

Question 40

A quarter of all candidates correctly processed this information correctly.

BIOLOGY

Paper 9700/21
AS Level Structured Questions

Key messages

- It is important that candidates are familiar with all the key terms in the syllabus and are given opportunities to practise applying them in a range of different topics. For example, in **Question 3(d)**, some candidates confused the term antibody with antibiotic, and the term immunity with resistance. In **Question 5(d),** some candidates confused the terms cohesion and adhesion.

- Candidates must appreciate the need for accuracy when describing of biological processes. For example, in **Question 5(a)**, many candidates described loss of water rather than loss of water vapour. Similarly, in **Question 5(c)** the term water potential gradient should be used rather than water concentration gradient.

- Candidates are reminded of the importance of spelling key terms correctly. In **Question 1(b)(ii)**, the term glycosidic was often misspelt. In **Question 6(a)**, candidates found the spelling of the stages of the cardiac cycle challenging.

General comments

The importance of reading the question was shown in **Question 3(d)**. Some described *Vibrio cholerae* as a virus even though the information that cholera is caused by a bacterial pathogen was given in the stem of the question. It is also important that candidates know that antibiotics cannot be used to treat viral infections.

In **Question 4 (b)(iii)**, candidates were directed to consider the effects of single stranded DNA on translation of the mRNA, and candidates are reminded to pay particular attention to terms that are in bold, such as translation in this question.

The importance of the correct use of key terms was demonstrated in **Question 4(a)(ii)**, where candidates had to show understanding of the term monomer and apply this to a DNA molecule. Only those with a secure understanding of the term were able to demonstrate knowledge of the structure of a nucleotide.

In **Question 5(d)**, some candidates confused the terms cohesion and adhesion. In **Question 5(c)**, candidates were required to describe the maintenance of the water potential gradient, however some candidates used the term water concentration gradient, which was not creditworthy. When answering **Question 5(d)**, very few candidates referred to cohesion-tension**.** In addition, when describing cohesion and adhesion, candidates should refer to water molecules rather than writing in general terms about water.

Question 1(b)(ii) and **Question 2(c)(ii)** asked candidates to make comparisons and give similarities and differences, and in both cases, candidates found it easier to state the similarities than the differences. It is important that both aspects are addressed for full credit to be awarded.

Comments on specific questions

Question 1

(a) (i) This was a straightforward question for many candidates**.** Most were able to name the large vacuole, and many also named the nucleus and chloroplasts correctly. The most common incorrect answer was to identify the nucleus as a mitochondrion. Some candidates also incorrectly identified the chloroplast as a mitochondrion. The vacuole was sometimes labelled cytoplasm.

Candidates should take care with the spelling of the term nucleus as an incorrect spelling could lead to confusion with the nucleolus and therefore not gain credit.

(ii) Many candidates gained full credit for this question and were knowledgeable about the differences between the structure of a plant and an animal cell. Some candidates confused the structure of a prokaryotic cell with that of the animal cell, stating that an animal cell has no nucleus or that it has no (double) membrane-bound organelles.

(b) (i) The strongest responses identified the chemical reagent used to test for starch as iodine solution. The most common incorrect answer was Benedict's solution, which is used to test for reducing sugars. Some answered the question and gave a correct colour change; others stated only blue-black and needed to reference the original orange-brown colour of the iodine solution. Successful candidates responded to the question carefully and paid close attention to the prompts given on the answer lines to guide their answers.

(ii) There were some very good answers to this question, in which candidates accurately identified similarities in the structure of amylose and amylopectin. Detailed responses identified both molecules as polymers or polysaccharides. Many knew that both were composed of the monomer alpha glucose or α-glucose and that these were linked by 1,4 glycosidic bonds. Reference to a-glucose was not accepted. Fewer went on to describe the bonding in the molecules and their different shapes. Some candidates confused the two molecules, describing amylose as branched or containing 1,6 glycosidic bonds. Weaker responses described polypeptides and tried to link knowledge of secondary and tertiary structure to these molecules. Candidates found it easier to discuss the similarities and some needed to go on to describe differences to gain full credit. Some candidates confused the structure of these polymers with other polymers they had learnt about, such as cellulose and collagen.

Question 2

(a) (i) Many candidates were able to correctly identify the red blood cell. The most common mistake was to identify the structure as something other than a cell, such as the nucleus.

(ii) Strong candidates thoughtfully interpreted the transmission electron micrograph and identified fluid **R** as tissue fluid. They then applied their understanding of the formation of tissue fluid to correctly identify a difference between the composition of tissue fluid and blood. The most common correct answers were the lack of red blood cells or plasma proteins in tissue fluid. All valid suggestions were able to gain credit. Many candidates who identified these differences were able to state size as the reason for the difference. Some could have improved their response by making it clear that these cells or large proteins could not fit through the pores between the endothelial cells that make up the capillary wall.

(b) (i) The majority of candidates gained credit for showing the phospholipids arranged as a bilayer. Most candidates drew each phospholipid with one phosphate head and two fatty acid tails. The most common incorrect drawing showed the number of fatty acid tails as one or three. Some candidates who had drawn two fatty acids were unable to gain full credit because the fatty acid tails of two phospholipid molecules were shown joined together in the hydrophobic core of the membrane, suggesting that the two molecules were just one molecule. Care should be taken when drawing diagrams to make sure the fatty acid tails join to the phosphate head.

(ii) Many candidates were able to identify a role of cholesterol in the membrane. Candidates who stated that cholesterol increases or decreases fluidity were only able to gain credit if they correctly linked this change to the temperature of the environment. Weaker answers suggested that the cholesterol provides energy to the cell.

(c) (i) The short-term effects of nicotine on the cardiovascular system were well known, with many gaining full credit. Some candidates tried to describe the effects of nicotine on other organ systems, such as the gaseous exchange system, and were unable to gain credit. Weaker responses described the effects of smoking on the body.

(ii) Candidates were required to apply their knowledge of the co-transport of sucrose to the unfamiliar example of the co-transport of nicotine described in the question. The strongest responses identified that both methods of co-transport involved membrane proteins and hydrogen ions (H^+ or

protons) and that the ions were moving down the concentration gradient into the cell. These higher achieving candidates often went on to describe the movement of sucrose and nicotine against a concentration gradient. It was quite common for weaker responses to incorrectly describe this as a difference, stating that sucrose moves down the concentration gradient into the companion cell. Fewer candidates were able to identify the differences between the two methods of co-transport.

Question 3

(a) There were some very good answers to this question and many candidates demonstrated their understanding of the transmission of *Vibrio cholerae*. Candidates who made reference to contaminated water or food but did not go on to describe that this contamination was from faeces or sewage, were unable to gain credit for their ideas. There were a small number of candidates who described the water or food as infected, and these answers did not gain credit. Some candidates remembered the role of flies in the contamination of food and gained credit for their understanding. The strongest responses clearly showed how the contaminated water or food was then eaten by an uninfected person. Some candidates incorrectly suggested that *Vibrio cholerae* could be transmitted by touch or by airborne droplets. Some candidates needed to take greater care to read the stem of the question as they incorrectly suggested that *Vibrio cholerae* is a virus.

(b) Most successful candidates identified **T** as an alpha helix. Candidates were not given credit for identifying **T** as 'a helix' rather than an alpha helix. Many went on to state that the alpha helix was part of the secondary structure and some made reference to the role of hydrogen bonds in maintaining the shape of the alpha helix. A number correctly described the hydrogen bonds forming between NH and CO of different amino acids. Weaker responses identified the helix as the double helix in DNA.

(c) (i) The majority of candidates who gained credit described the importance of the lysosomes found in phagocytes in digestion and made reference to the hydrolytic enzymes found within the lysosome. A number also described the lysosomes fusing with the phagosome. Weaker responses recognised the role of phagocytes in the immune response but described the importance of an immune response rather than focusing on the function of lysosomes. A small number of candidates suggested the lysosomes themselves were digestive enzymes.

(ii) The most common correct advantage given was that dead cells will trigger an immune response without causing disease. A few candidates recognised the significance of using only one part of the choleragen molecule in the vaccine. Strong responses recognised that the different antigens in the vaccine would stimulate the production of different antibodies and different types of memory cells. Some candidates suggested that the vaccine was more likely to be effective or that the immune response would be stronger and therefore perhaps only one dose of the vaccine would be necessary. These answers showed good application of understanding about the immune response and credit was awarded for these ideas.

(d) This question was well answered, with many candidates showing a good understanding of the consequences of the development of antibiotic resistance in *Vibrio cholerae*. The most common correct ideas were that there would be an increased risk of spread to others and an increased death rate. Weaker answers described people as having resistance to antibiotics rather than bacteria and used the terms antibiotic and antibody interchangeably. Some candidates confused the ideas of resistance and immunity, describing the bacteria as immune to antibiotics.

Many candidates recognised the need for research to develop new antibiotics and some referred to the cost implications of this and the difficulties this may present in some countries. A small number of the more able candidates took their ideas further and discussed the consequences of the transfer of the resistance allele to other species of bacteria. Many candidates could have improved their answers with discussion of this consequence of antibiotic resistance.

Question 4

(a) (i) There were some very good descriptions of the spindle fibres pulling daughter chromosomes or sister chromatids to opposite poles of the cell. This was the most commonly awarded marking point. A few candidates referred to the spindle fibres being attached to the centromere and included a description of the spindle fibres contracting to pull the daughter chromosomes. Weaker

responses were unable to identify the stage of mitosis shown in **Fig. 4.1**, with the most common error being that the cell was in metaphase.

(ii) Some candidates were not able to identify the monomer of a DNA molecule as a nucleotide. Knowledge of the structure of a nucleotide was variable, with some candidates drawing a nucleotide but incorrectly identifying the three component parts. Common mistakes were to identify the sugar as ribose rather than deoxyribose and to confuse the terms nucleotide and base.

(b) (i) Knowledge of stem cells was generally good, with a large number of candidates able to state that stem cells need to be able to divide repeatedly. Some went on to explain why this was important, linking it to the role of the stem cell in producing cells for cell replacement and for tissue repair. Reference to the importance of a stem cell being able to self-renew was made by a small number of candidates.

(ii) Candidates answered this question well, with many able to describe the uncontrolled mitosis that occurs when a cell becomes cancerous. Weaker responses described uncontrolled growth of cells and did not qualify this correctly with uncontrolled mitosis or uncontrolled cell division.

(iii) The question required candidates to think carefully about the information provided in the question stem. Good answers recognised the significance of the DNA being single-stranded and having a complementary base sequence to a section of the mRNA. Those who identified the significance of this information were credited for their descriptions of the DNA binding to the mRNA. A few candidates developed this idea further and wrote about how this might prevent translation of the mRNA. The strongest responses suggested that the ribosome would not bind to the mRNA or that the tRNA anticodons would be unable to bind to the mRNA codons. Weaker responses suggested that the single stranded DNA introduced into the cell coded for telomerase and suggested that it would not be able to be transcribed. These suggestions did not answer the question asked.

Question 5

(a) Those gaining full credit described the loss of water vapour from the leaves or aerial parts of a plant. Candidates who simply described the loss of water were not able to gain full credit without showing they understood that water has evaporated from the cells walls of the spongy mesophyll cells into the air spaces and diffuses out of the leaves as water vapour. Candidates who described loss of water vapour through stomata without further detail needed to identify where this process is taking place, by stating the leaves or aerial parts of the plant.

(b) Most candidates were able to calculate a mean rate of movement of the bubble. A few realised that the question required them to divide this value by ten. This was necessary as the units were mm min^{-1} on the answer line and the units in the table were mm in 10 minutes. Many candidates showed their working very clearly.

(c) Successful responses described water vapour being blown away from the leaves as an explanation for the increase in the rate of transpiration. Candidates who wrote about water molecules rather than water vapour gained credit for their understanding of the role of wind in moving the water molecules away. Candidates who wrote only in terms of water moving were unable to gain credit. The strongest answers described the maintenance of the water potential gradient. Some candidates described a water concentration gradient and this was not credited. Very few candidates developed their ideas and described the higher rate of evaporation into the air spaces.

(d) Most candidates were able to demonstrate understanding of how water moves up through a xylem vessel in the stem. Many described the importance of cohesion and adhesion, showing a clear understanding of these two processes. Some candidates confused these two terms and so did not gain credit for their descriptions. Candidates needed to describe these two processes in terms of water molecules rather than stating simply that water is cohesive and adhesive. Some answers were detailed and went on to describe transpiration pull and water moving as an unbroken column. Some also referred to cohesion-tension.

Question 6

(a) Many candidates answered this question with confidence, correctly identifying the stage of the cardiac cycle as atrial systole. The most common error was to name the stage as diastole. Most

candidates were able to give evidence to support the identification of the stage, with the majority describing the flow of blood into the ventricles.

(b) (i) Many candidates correctly identified the position of the semilunar valves. The most common error was to label the atrioventricular valves.

(ii) This question was answered well, with the majority of candidates gaining credit. The role of the valves in preventing backflow of blood was well known. Some gave more detailed answers and went on to develop this idea, linking the role of the semilunar valves in preventing backflow from the arteries into the ventricles.

BIOLOGY

Paper 9700/22
AS Level Structured Questions

Key messages

Carrier proteins and channel proteins are both membrane transport proteins. In **Question 1(b)**, where candidates were asked to describe how these are involved in the transport of substances into and out of cells, it was a common error to state that carrier proteins carry out active transport while channel proteins carry out facilitated diffusion. Candidates should also be aware that there are carrier proteins that also carry out facilitated diffusion.

Candidates frequently had difficulty distinguishing between the two command terms 'describe' and 'explain'.

- **Question 4(b)(ii)** required an explanation for the difference in results shown in **Fig. 4.1**. This could be achieved by applying syllabus knowledge and understanding of transpiration and stomata. However, many incorrectly described the differences in results shown in the graph, without using any biological knowledge that could be credited as an explanation.

- **Question 6(a)** required a description of a method using immobilised amylase that was based on the ideas shown in **Fig. 6.1**. Here, many gave theoretical explanations involving enzyme catalysis, diffusion and surface area to volume ratios. The biology was often correct but did not answer the question, which required statements of the main steps of the experimental procedure.

General comments

Those candidates who gave an overall very good performance were very knowledgeable of the syllabus content and were confident in applying their understanding to those questions that were set in an unfamiliar context. There were others who had clearly worked hard to cover the syllabus content and provided many correct points when answering questions; these could have improved their answers by going further to give more points to gain the maximum credit allocated to each question.

When asked to complete a table of differences between two cell types, it is sometimes acceptable to describe a feature that is present in one cell type and to then state that the feature is absent in the other cell type. However, it is essential to read all the information provided before starting to complete the table. In **Question 1(a)**, some stated that the cell wall was absent in a bacterial cell and present in a plant cell, even though the introduction to the question and the heading in the first column of **Table 1.1** explained to candidates that the structure was present in bacterial and plant cells.

In **Question 1(d)**, some candidates identified more than two cells in **Fig. 1.2** that are in different stages of mitosis. This was not necessary and often led to only partial credit being achieved due to errors in additional labels, even if two correct labels were given.

Question 2(c) and **Question 5(c)(ii)** highlighted confusion with red blood cells and haemoglobin. A proportion of candidates wrote about red blood cells as if they were molecules and described the cells as binding to oxygen, or to carbon monoxide. These responses needed to make clear that red blood cells each contain many haemoglobin molecules and it is these molecules that bind oxygen (or carbon monoxide).

In **Question 2(d)**, candidates found it easier to use the term 'less negative water potential' for 'higher water potential' and 'more negative water potential' for 'lower water potential', which is always acceptable.

In **Question 3(c)**, candidates were guided to use **Fig. 3.1** and **Fig. 3.2** to describe the structure of a polyhedrin molecule. Many only used **Fig. 3.2**, which showed two ribbon diagrams, to help them answer and

missed the opportunity to gain full credit for the question without use of **Fig. 3.1**. In extended answers such as these, it can be an advantage for candidates to keep to short sentences and only include one idea within each sentence.

In **Question 4(b)**, candidates had to apply knowledge and understanding to answer questions about an experiment involving three different grapevines of the Barlinka variety. In **Question 4(b)(i)** and **(ii)**, candidates who had read the introduction to **Question 4** understood that the results shown in **Fig. 4.1** for the rate of flow of xylem sap over three days could be used as an estimate of the rate of transpiration over this time period. Not all candidates used the information provided and lost available credit as a result.

Comments on specific questions

Question 1

(a) Most candidates understood that a correct description needed to be given for both cell types when completing **Table 1.1**. The difference in size of ribosomes was well known, with few getting this the wrong way round. There were three different ways to gain credit for DNA and candidates needed to provide a matching difference to gain credit, which most did. One error was to suggest that naked DNA meant not enclosed in a nuclear envelope, rather than an absence of histone proteins. Most knew that the cell wall was made of cellulose but there was greater difficulty in remembering the main component of the bacterial cell wall, and chitin was given incorrectly by some candidates. A number did not know the correct spelling of murein and cellulose.

(b) There were some comprehensive responses here. The roles of channel proteins in facilitated diffusion and carrier proteins in active transport were frequently stated; fewer remembered that carrier proteins also carried out facilitated diffusion. Many gave further correct details of each type of protein. Some gave general points about the transport of substances across membrane proteins and because there were a number of differences between the two types, needed to make it clearer whether they were writing about carrier or channel proteins.

(c) The strongest responses reflected an ability to think about the relationship within the cell of the various structures and correct explanations for the presence of chloroplasts around the periphery of the plant cell were based on the presence of the large central vacuole. Many knew about the role of chloroplasts and suggested ideas related to the need for light energy for photosynthesis. These responses presented an attempt at giving an advantage for their location rather than an explanation as to why they were in that location.

(d) There were only two stages of mitosis visible in **Fig. 1.2** and many candidates correctly labelled and identified one of the cells in prophase and the only cell in metaphase. This was sometimes labelled anaphase. Some candidates added a third labelled cell, usually giving interphase, which is not a stage of mitosis.

Question 2

(a) Most knew that red blood cells and plasma proteins are too large to leave the capillary, and more detailed answers gained full credit by showing knowledge of the presence of endothelial pores. Weaker responses missed this point and only wrote about the capillary wall being a barrier. Some incorrectly described albumin molecules as cells, or red blood cells as molecules, or stated that red blood cells were not flexible enough to squeeze through to enter tissue fluid.

(b) Although it was clear that many remembered the biuret test for proteins, a very wide range of incorrect spellings was seen for the term. It was acceptable to state as an alternative the two solutions used to prepare biuret solution. To gain full credit, it was necessary to state the initial colour of biuret solution as well as give the colour of a positive result for protein. A common error was to state that biuret solution is colourless, rather than pale blue or blue. Some did not state the initial colour of the solution before the test was carried out. Weak responses named solutions to test for other biochemicals, such as Benedict's solution or iodine solution.

(c) There were many good answers to this question, with some candidates giving all the expected points. A good understanding of the role of haemoglobin was shown and the concept of compensation was outlined accurately. Others were less precise and wrote about decreased saturation of red blood cells and lower affinity of red blood cells for oxygen. To gain credit,

reference to haemoglobin was needed. Some stated that an increase in red blood cells would provide the body with more oxygen, which is not correct.

(d) The introduction to **Question 2** explained that plasma proteins allow movement of water back into capillaries at the venous end. From this, candidates could deduce that a lowered blood albumin concentration compared to normal would mean fewer solutes. Blood arriving at the arterial end of the network would therefore have a higher (less negative) water potential than normal. Candidates who only wrote that the tissue fluid had a lower (more negative) water potential were not given credit, as this would be the case in people without the condition. Good responses showed an understanding that an accumulation of tissue fluid resulted also from less water than normal returning to the capillary at the venous end of the capillary network, and so covered both aspects to gain full credit. Weaker responses suggested that lowered blood albumin lowered water potential or that albumin could enter tissue fluid. Consequently, these ideas produced some confused responses.

(e) Many correctly named receptors or receptor proteins as the type of membrane protein that binds signalling molecules. Some gave the creditworthy response of glycoprotein, which is a more general answer because these proteins have more than the role of binding signalling molecules. Common incorrect answers were 'G-proteins' and 'receptor cells.'

Question 3

(a) The information given at the beginning of **Question 3** was read with care by many candidates, who correctly explained that the virus was a pathogen that could be transmitted from insect to insect and cause harm. Others did not apply their knowledge to the example and wrote about disease transmission from person to person or plant to plant.

(b) The description of polyhedrons included the detail that the main component of the protective structures was the protein polyhedrin. Candidates were not expected to know about the alkaline conditions in the insect gut but, given the information about the structure of polyhedrons, could apply knowledge to make biologically valid suggestions. Acidic or alkaline conditions were also suggested, and both were credited. Many suggested that enzymes were present, and to gain full credit a link to proteins or polyhedrins was required, with some further qualification. Some suggested that lysosomes were present, forgetting that these are cellular structures, so would not be present in the gut lumen.

(c) Information about the structure of a polyhedrin molecule was provided in **Fig. 3.1** and **Fig. 3.2**. Complete answers used **Fig. 3.1** to remind them to describe primary structure in addition to the other three levels of protein structure in **Fig. 3.2 A** and **Fig 3.2 B**. Some planned their response to describe the structure in a clearly expressed, sequential manner using the correct terminology. Others provided the information in a more disorganised fashion, frequently amalgamating details about secondary and tertiary structure, or tertiary and quaternary structure, into one sentence that lacked clarity.

(d) Some candidates correctly gave features of the genetic code that would account for the inability to deduce a sequence of nucleotides from a sequence of amino acids. Some were able to provide additional information that could be credited, such as the post-transcriptional removal of introns to form mRNA. Stronger responses used correct scientific terminology and described mRNA codons or DNA triplets. A proportion of these remembered to name the genetic code as such and to state that the code was degenerate or explained the degeneracy clearly. Some used the incorrect term 'degenerative' or used the term 'code' for 'codon'. Others did not use a term or did not make it clear that it was a group of three nucleotides that coded for an amino acid. Weaker responses gave vague descriptions of translation.

Question 4

(a) Most candidates knew that 'cohesion' and 'adhesion' were the correct terms. Of those gaining partial credit, this was often because they could only state 'cohesion' or that they wrote the terms the wrong way round.

(b) (i) **Fig. 4.1** showed a very clear night and day pattern for transpiration rate for all three grapevines and this feature was noted by some candidates. Candidates found it more difficult to gain further credit, with fewer relating the differences to stomatal opening during the day and closure at night. A small

number of responses linked the increase or decrease in rate to degree of stomatal opening at different times of the day.

It was quite common for candidates to interpret the pattern of changes in transpiration to a pattern of photosynthesis, which was not the focus of the question. Many had taken into account that the plants were growing in the same conditions, but some had greater difficulty expressing themselves well enough to gain credit. These weaker candidates wrote that the plants were in the same conditions and so the transpiration rate was 'the same', when clearly **Fig. 4.1** showed that the rates were different for the three different plants. More fluent answers explained that external conditions affecting the rate of transpiration would be affecting the plants in the same way as they were all growing in the same conditions.

(ii) Strong responses showed that the results provided in **Fig. 4.1** had been used to explain the relationship shown between the different total leaf areas of the grapevines and the rate of transpiration. Clear statements were made linking the increase in total leaf area to an increase in the number of stomata and hence a greater rate of transpiration. Some gave a correct relationship but did not qualify this with reference to stomata. Many did not pay attention to the command term to 'explain' and gave lengthy descriptions of the results, so did not gain any credit.

(iii) In **Fig. 4.1** there was a clear dip in the rate of flow of xylem sap for all three grapevines during the day on day 3. A range of valid explanations were suggested by many candidates. Some needed to be more precise and credit was not given for vague responses such as a 'change' in humidity, light intensity or temperature. The rate of flow of xylem sap did not dip to a low value and soon increased again, so responses suggesting that all the stomata were closed because of a change in an external factor or because it was night were not credited.

(iv) There were some detailed explanations of how to determine the surface area of one side of a leaf, with the great majority using graph paper or a grid. This suggested that many had carried out experimental work or were able to consider what they would do in a practical situation. Some attempted to apply knowledge of calculating surface areas of fixed shapes and suggested measuring lengths and widths, which would not have worked for this situation.

Question 5

(a) Most knew that ribose was the pentose sugar of a RNA nucleotide and for the weakest responses this was the only correct answer given. A good understanding of which bases were purines and which were pyrimidines was shown by most others. Errors that were made here were to give the two sets of base pairs or to name thymine instead of uracil. The type of covalent bond between RNA nucleotides was far less commonly named. Hydrogen bond was a very frequent incorrect answer.

(b) There were many well-expressed answers to describe how measles is transmitted. These described the person with the pathogen as 'infected' and the person who did not have the pathogen as 'uninfected' and used other acceptable scientific terms including 'droplet infection', 'aerosol infection' or 'airborne droplets'. Some also described a correct contact transmission route. To gain credit for this, it had to be clear that the surface touched was contaminated with *Morbillivirus* and that the uninfected person would pass this to their mouth, nose or eyes to be taken into the gas exchange system. More vague ideas that could be interpreted as infection by eating or drinking were not credited.

(c) (i) The majority knew the main structures of the gas exchange system and could list them in sequence to complete **Fig. 5.1**. Where credit was not given, this was usually because the spelling of 'bronchiole' was insufficiently clear.

(ii) Only the short-term effect of carbon monoxide on the cardiovascular system needed to be stated, so good answers focused on how carbon monoxide would affect the ability of haemoglobin to bind to oxygen and the direct consequence of this in terms of the transport of oxygen to body tissues. Some incorrectly described binding to red blood cells. Carbon monoxide is known to damage the endothelium and this was also credited as a short term effect. References to longer-term effects, such as possibly contributing to atherosclerosis or peripheral vascular disease, were ignored.

(d) (i) This straightforward question presented few problems for candidates. Because the question did not include any reference to the *y*-axis, it was important in the answer to acknowledge what was

shown on the *y*-axis, which meant that answers that only stated 'there is an increasing trend' or 'there is an increase between 2000 and 2017', were not credited. Some incorrectly interpreted the *y*-axis as a death rate.

(ii) Some candidates gave several different, valid reasons for the trend shown in **Fig. 5.2** and gained full credit; others concentrated only on the immunological consequence of not being vaccinated. Often detailed explanations involving the primary and secondary immune responses were given. This kind of answer was too focused to gain full credit: firstly because there were many other reasons that could have resulted in the trend shown, and secondly because the response included ideas that were more pertinent to a 'suggest and explain' style of question. Some reasons given were too vague to be credited. For example, 'living in overcrowded countries' as a reason does not necessarily increase the number of deaths, but 'overcrowded living conditions' implies greater exposure to disease transmission.

(e) Strong responses showed an understanding that leukaemia is a cancer of white blood cells and that the high cell count is as a result of uncontrolled division rather than of clonal expansion. These responses were qualified further to explain the lack of function of the cells in providing immunological protection in situations of both natural and artificial active immunity. Some answers ignored the information given and gave general explanations as to why a child could be more at risk of measles, such as through a lack of vitamin A or malnourishment. Others, who did not know the link between leukaemia and a high white blood cell count, explained that the disease caused the death of the cells of the immune system, or that immune system cells were too preoccupied with targeting cancer cells to be able to defend against *Morbillivirus*.

Question 6

(a) Good descriptions of an improved method based on **Fig. 6.1** were comprehensive enough to show that the procedure would:

- increase the contact time of the substrate, starch, with the amylase enzyme immobilised within the alginate beads;
- be carried out at the optimum temperature for the enzyme used;
- produce reducing sugar only.

Many candidates gave one or two ideas that could be credited as they were related to an increased contact time, either by use of the taps in the experimental set-up, by running the product through the column a sufficient number of times, or by suggesting a relevant modification. The most common of these were to either use smaller or more beads. Far fewer remembered to mention using an optimum temperature or to include as part of their method a check to make sure that the product did not contain starch. Instead, many candidates referred to a use of the Benedict's test. Although the general idea of testing for starch in the product was credited, good answers stated that samples should be taken for testing so that the product would not be contaminated with the testing reagent.

(b) Many gave a valid reason to explain how using either larger or smaller beads in the column shown in **Fig. 6.1** would affect the results obtained. Most of these chose to write about the increased surface area to volume ratio or overall increased surface area for the smaller beads, or vice versa for the larger beads. Some stated a difference between the two, for example stating that they would have different (overall) surface areas or that the starch would flow through the column at different rates. To gain credit, this needed to be qualified by giving detail of either the larger or smaller beads.

BIOLOGY

Paper 9700/23
AS Level Structured Questions

Key messages

Candidates need to be aware of the different command words used in questions. For example, they should be able to distinguish between the command terms 'predict' and 'explain' and between 'describe' and 'explain'.

- In **Question 2(b)**, candidates were asked to predict results for an experiment involving the enzyme pepsin. In **Question 2(b)(i)**, they were asked to predict results using a competitive inhibitor and in **Question 2(b)(ii)**, predict results using a lower temperature. Many candidates gave explanations instead of predictions.
- In **Question 3 (b)(i)**, candidates were asked to describe changes in the results shown in **Table 3.1** for mean percentage saturation of haemoglobin with oxygen and the mean haemoglobin concentration in blood. A proportion of answers were explanations of the trends shown in **Table 3.1** instead of descriptions.

Candidates should read the questions carefully and check that their answers match the question. In **Question 4(a)**, some candidates wrote about the structure of collagen instead of a cellulose microfibril. Here, answers included references to polypeptide chains and triple helices. Some described how cellulose molecules were arranged into a microfibril, as required, but wrote 'collagen' rather than 'cellulose'. In their answers to **Question 3(b)(i)**, some candidates described changes to the mean oxygen concentration in blood leaving the lungs, having used the wrong column of results, or did not accurately transcribe the correct units for mean haemoglobin concentration.

It is essential that candidates have a good command of the correct terminology for each topic on the syllabus. Many candidates referred to R groups in their answers to **Question 1(b)**, but it was not always clear exactly what changes they were describing and how these would affect the structure of the β-globin polypeptide.

General comments

Most candidates attempted all the questions on the paper. Answers from the strongest candidates were fluent and revealed an excellent understanding of the topics assessed. Others made fair attempts at the questions and could have improved further if they had a greater proficiency in examination technique. Some candidates were less confident in their knowledge and their ability to provide the correct biology for the questions posed.

Candidates should avoid use of general terms such as 'it changes', 'it affects' and 'are different' without further qualification. For example, in **Question 1(b)**, statements such as 'it changes the structure of haemoglobin' were a variation of the question being asked and offered no extra detail. Candidates should also be specific in their answers. Answers to **Question 5(c)** on vaccination often included statements that were vague or ambiguous. Many candidates simply stated 'boosters for children' without making it clear that these have not been administered and so would increase the chance of transmission of measles rather than helping to eradicate the disease.

In **Question 2(b)**, candidates often did not realise that **Fig. 2.1** was a graph showing the progress of a reaction and not a graph of initial rate of reaction against substrate concentration. The graph in **Fig. 2.1** could not be used to determine the maximum rate of reaction, V_{max}, and the Michaelis-Menten constant, K_m.

Comments on specific questions

Question 1

(a) (i) Many candidates identified the stage of protein synthesis shown in **Fig. 1.1** as translation. Transcription and mRNA were common errors.

(ii) The majority of candidates were able to correctly identify **A**, **B** and **C** in **Fig. 1.1**.

(iii) AAA and GUG were given as the base sequences missing from **Fig. 1.1** on most scripts. A large number of candidates forgot that in RNA, uracil replaces thymine and wrote GTG instead. Some wrote the sequence TTT.

(b) This question was a more general question about the potential effect of changing an amino acid in the β-globin polypeptide of haemoglobin. Some candidates gave answers that matched this question exactly but others began their answer with descriptions of changes to the DNA nucleotide sequence of the *HBB* gene, mRNA codon and tRNA anticodons, which was not needed. Candidates who used the example of the sickle cell allele and wrote correctly about changes to the structure and function of a molecule of haemoglobin in relation to this, were able to gain credit. Weak responses assumed that a change in an amino acid leads to a change in the codon or nucleotide sequence of mRNA and DNA, rather than the other way around.

Some candidates demonstrated a good understanding of the levels of protein structure and gave excellent answers detailing the changes that occur as a result of the change to an R group. Other candidates did not make this change clear. Some wrote about haemoglobin having an R group, instead of individual amino acid residues having R groups. They stated that there are different bonds or interactions between R groups but were vague as to the effect that a change in R group would have.

Many candidates were confused between molecules of haemoglobin and red blood cells. For example, candidates wrote about the shape of a haemoglobin molecule changing from biconcave to sickle-shaped. Some candidates were unsure about the levels of complexity of proteins and how the change would affect them. Candidates were often confused about the positions and role of R groups. Some referred to different interactions between R groups without giving more detail of these interactions.

Question 2

(a) Candidates used a variety of methods to calculate the initial rate of reaction. Most drew a tangent to the curve in **Fig. 2.1**. Rates between 0.6 and 0.8 $\mu mol\,dm^{-3}\,min^{-1}$ were accepted. Most candidates gave rates to one decimal place. Those who gave their answers to two or more decimal places were credited if their answers were in the range 0.55 to 0.84, because rounded to one decimal place this would be within the accepted range. Other ways to show the units were credited, such as $\mu mol\,dm^{-3}$ per min and $\mu mol\,dm^{-3}\,s^{-1}$ or $\mu mol\,dm^{-3}$ per s. Some candidates spent time trying to convert figures to $mol\,dm^{-3}s^{-1}$ and often made mistakes.

(b) (i) Candidates were asked to predict the results that would be obtained from the investigation if repeated with a competitive inhibitor at the same temperature. Accepted predictions referred to a decrease in the initial rate so that there would be an increase in the time taken to complete the reaction but without any change to the final concentration of product (10 $\mu mol\,dm^{-3}$). Many candidates did not make a prediction but explained the effect of the competitive inhibitor on the activity of pepsin, and so gained no credit. Many misinterpreted the graph and commented on V_{max} and K_m. Many candidates made comments about the rate of reaction rather than the initial rate of reaction. Some candidates only referred to 'product concentration' and not the final or end concentration or an equivalent. Comments on how the angle, slope or gradient of the curve would change were not accepted.

(ii) Candidates who showed insight in **Question 2(b)(i)** tended to gain credit for applying these ideas here. Explanations of the effect of an increase in the temperature of the reaction mixture were not accepted. Some candidates suggested that the enzyme would be denatured at 30 °C, even though the question states that the pepsin comes from the stomach of a mammal.

(c) Some candidates were able to state an advantage of calculating the initial rate of the reaction when investigating the activity of the same enzyme from two different species. Good answers stated that the initial rate is the fastest rate and is not limited by the subsequent decrease in substrate concentration. Candidates also stated that choosing to measure the initial rate allowed a valid comparison between the activity of the two enzymes. Many stated that this allowed the experimenters to compare the enzymes, without referring to the activity of the enzymes or to the rate of the reaction catalysed by the enzymes.

Question 3

(a) (i) Many answers gave two suitable features of the red blood cells shown in **Fig. 3.1**. A common correct answer was to state that the red blood cells did not have a nucleus or any other organelles, such as mitochondria. A number of candidates noted the flexible nature of red blood cells, having observed the variety of shapes visible in **Fig. 3.1**. The transmission electron micrograph shows the endothelial cells forming the wall of the capillary. Many candidates stated that the red blood cells have the 'same diameter as the capillary' and should have realised that 'the capillary' in their answers included the endothelial cells, meaning that red blood cells are narrower in diameter. Stronger answers stated that the diameter of the red blood cells is about the same as the lumen of the capillary. Some candidates calculated the actual diameter of the red blood cells in the image, although some lost the credit available for this by giving the wrong unit, for example nm instead of μm. Candidates also stated that the red blood cells have a biconcave disc shape, which is not visible in **Fig. 3.1**.

(ii) Candidates who stated how the composition of tissue fluid differs from blood gained credit only if they gave a clear comparison. Many candidates included the absence of red blood cells and platelets in tissue fluid. Some of these respondents stated that there are fewer white blood cells than found in blood. Some wrote 'tissue fluid has no cells' without any further detail and this gained no credit. Candidates were not always correct in their statements about proteins. Some stated correctly that there were 'no plasma proteins' or 'no large proteins'. Some stated that there were no proteins at all, which was not accepted. Good answers concentrated on the substances that are exchanged between blood plasma and tissue fluid, stating that there are lower concentrations of glucose and oxygen in tissue fluid.

(b) (i) Most answers gave qualitative descriptions of the trends shown in **Table 3.1**. Fewer candidates used figures from **Table 3.1** to include a comparative data quote. Some candidates did not follow the instruction to describe the changes and gave explanations for the trends instead. These explanations, often very well written, did not gain credit. Several did not quote supporting units or made errors when quoting units. Where data was quoted, some candidates related this to the location rather than to the altitude in metres. Some candidates gave descriptions of how the oxygen concentration in the atmosphere changes with altitude.

(ii) Candidates were expected to use the data in **Table 3.1** to make suggestions about the differences that allowed people living at high altitude to have a similar oxygen concentration in their blood as those living at low altitude. Those who simply repeated data from **Table 3.1** did not gain credit. Many candidates stated that there are more red blood cells in the blood of people who live at high altitude. Qualifying this with the concept that there would be more haemoglobin did not gain further credit as this was shown in the table. Some candidates used knowledge additional to syllabus requirements and suggested that there would be more erythropoietin (EPO), and that this would increase the production of red blood cells. This could also be credited, together with the statement that there is more haemoglobin in each red blood cell. A few candidates gave responses of a greater breadth and made correct suggestions about changes in the gas exchange and circulatory systems that existed in people who live at high altitude, such as larger lungs and a higher cardiac output.

Question 4

(a) Candidates were often unclear about the arrangement of cellulose molecules in microfibrils. Some described only the structure of a cellulose molecule. Others confused cellulose with collagen and wrote about the structure and arrangement of triple helices. The strongest responses explained that the straight, unbranched molecules of cellulose are aligned in parallel and are held together by hydrogen bonds. Some candidates described the arrangement of hydrogen bonds very clearly, but in other responses there were confused descriptions. Descriptions of the arrangement of

microfibrils into cellulose fibres were not required. Candidates should take care to distinguish between cellulose molecules and cellulose fibres.

(b) (i) There were many excellent diagrams showing a channel protein in a cell surface membrane that easily gained full credit. Common errors were to show a monolayer of phospholipids, or to omit any labelling, or to draw the channel protein as a cross-section (similar to the drawing of the stoma and guard cells in **Fig. 4.1**), rather than in longitudinal section. Some drew a carrier protein with the two sides blocking the passageway through the centre. There were some candidates who did not draw anything resembling a phospholipid bilayer, drawing a single or a double line.

(ii) Many candidates gave clear explanations of the need for channel proteins for the movement of ions, which included using correct scientific terminology. Vague answers wrote about movement across the membrane rather than explaining that the proteins provide a hydrophilic pathway for ions because they cannot pass directly through the phospholipid bilayer. Some explained this by stating incorrectly that ions are polar, or polar molecules, rather than that ions are charged. A number of candidates correctly wrote about facilitated diffusion, although weaker responses stated active transport instead.

(c) Candidates were presented with an unfamiliar context of a particular variety of a plant, *Arabidopsis thaliana*, that does not have channel proteins for the outward movement of ions from guard cells. Most candidates used the information provided to suggest that stomata would not close. A proportion of these went further to deduce that, without ions moving out of the cells, water would not leave by osmosis down a water potential gradient and so guard cells would remain turgid. Candidates often stated that the rate of transpiration would change. Stronger responses explained that if stomata cannot close, the transpiration rate will remain constant until there is a change in the environmental conditions that influences the rate of diffusion of water vapour through the stomata. Many candidates did not appreciate that, for this variety, transpiration will continue at night.

Question 5

(a) (i) Many knew that *Morbillivirus* was the causative organism of measles, and a high proportion of these knew the correct spelling. The most common incorrect spelling was *Morbilivirus*.

(ii) There were many correct descriptions of the transmission of the virus. Most candidates made it clear that the virus is transmitted when an infected person sneezes or coughs, releasing airborne droplets that are inhaled by an uninfected person. Several weaker responses stated that measles is an ‘air disease’ or listed every possible route of transmission as a list, e.g. via water, air, food, body fluids or sewage.

(b) The strongest descriptions of the data shown in **Fig. 5.1** considered the full years 2015 to 2018 and identified a pattern showing peaks occurring only in the first part of each year. Many also correctly noted that fluctuations occurred in the number of cases of measles. Some were able to gain further credit by correctly identifying the month with the highest or lowest number of cases as January 2019 and March 2019 respectively. Some candidates simply wrote out the numbers of cases in specific months rather than described the pattern of cases. Many misread the axes, giving February 2019 as the month with the highest number of cases and taking the wrong figure for the number of cases from the vertical axis.

(c) There were two ways to approach this question. Some candidates concentrated on the ideas of controlling and preventing transmission and on considering susceptibility to the virus, while others concentrated on the reasons for low rates of immunisation. The majority of candidates gave two or three points from each approach. Many explained that as measles is highly infectious, a very high percentage cover is required to achieve herd immunity and to break the transmission cycle. Various reasons why this is not achieved were given, including the resistance of many people to having their children vaccinated. Suggestions that were not accepted were the cost of the vaccine, as this is provided by health authorities for free or by organisations such as UNICEF. One particular problem with measles is vaccinating infants at the time that they lose the passive immunity gained from their mothers. Some candidates knew that vaccinating infants too early will not stimulate an immune response and understood that a delay in vaccinating after passive immunity is lost will put infants at risk of measles. A few candidates referred to the thermostability of the vaccine but did not explain that this presents difficulties in maintaining a cold chain.

Question 6

(a) Many candidates completed **Table 6.1** correctly. Common errors were to omit P from row 1 for DNA, or include S as well as CHONP, or to state the bases ATCG. Many gave nucleic acid(s) instead of nucleotides for row 2 for DNA. Hydrogen bonds were frequently given instead of phosphodiester bonds for DNA in row 3. Glycosidic bonds rather than peptide bonds appeared in row 3 for collagen, and sometimes for DNA as well.

(b) A few candidates stated clearly that the nuclear envelope is composed of two membranes and that the nuclear pores are too small to allow DNA to pass out into the cytoplasm. Some of the strongest responses also suggested protective functions, such as the protection of DNA from the action of hydrolytic enzymes in the cytoplasm. There were many weak responses, with a number of candidates giving answers that were not relevant to the question, instead writing about the movement of mRNA from the nucleus through nuclear pores to the cytoplasm.

(c) Some candidates wrote about the alveoli in their answers, correctly explaining that elastic fibres stretch during inhalation and recoil during exhalation. Many explained that the recoil helps to force air out of the alveoli. Most candidates stated that elastic fibres prevent the alveoli from bursting. Some candidates who wrote about lung tissue, rather than specifically about alveoli, correctly referred to ‘expand and recoil’, which was more appropriate than ‘stretch and recoil’.

(d) Almost all candidates gave interphase or the S phase as the stage of the cell cycle when DNA and proteins are synthesised. A proportion of these were not credited because they also included the G1 phase of interphase.

BIOLOGY

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 so that they develop the skills that can be applied to the requirements of the examination.

Where questions use wording such as 'show all the steps in your working', candidates should clearly state all the steps in their calculation and relevant reasoning. The answer should be shown to the correct degree of accuracy. Candidates should use the correct number of significant figures for calculated quantities. This should be the same number of significant figures as (or one more than) the measured quantity of least accuracy.

General comments

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

Comments on specific questions

Section A

Question 1

(a) (i) Many candidates were able to carry out a serial dilution of the 1.0% protein solution, showing the correct concentration below each beaker (0.5%, 0.25%, 0.125% and 0.625%) and transferring 10 cm^3 of the previous concentration to the next beaker and adding 10 cm^3 of distilled water to each beaker. The most common error was omitting the protein concentration of 0.625%.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for the independent variable as percentage protein concentration and the colour symbol for the dependent variable. Most candidates recorded readings for all the protein concentrations using symbols.

(iii) Many candidates correctly stated that the independent variable in the investigation was the concentration of protein.

(iv) The majority of candidates recorded the result for **U** using symbols.

(v) Many candidates correctly completed the scale in **Fig. 1.2** by showing the correct positions of their protein concentrations.

(vi) Some candidates correctly showed their estimate of **U** in **Fig. 1.2** by drawing an arrow at the correct position on the scale.

(vii) Some candidates correctly stated the medical condition of the patient as indicated by **U**.

(viii) Some candidates correctly stated that repeating the test at least three times would confirm that their result for **U** was correct.

(ix) Some candidates correctly suggested that to obtain an estimate of the concentration of glucose in the sample of urine, they would carry out the Benedict's test on at least three known concentrations of glucose and then carry out the Benedict's test on the sample and compare the result for the sample with the known concentrations of glucose.

(b) (i) Most candidates used the headings given in the table to correctly label the *x*-axis, antibiotic (including the labels for each of the different antibiotics in **Table 1.4**), and the *y*-axis, percentage of resistant bacteria. Some candidates, however, labelled the incorrect axis or gave incomplete headings. Most candidates drew bars of equal width and distance apart on the *x*-axis, used a scale of 10 to 2 cm for the *y*-axis and plotted each bar accurately. The stronger candidates drew ruled lines for the bars so that the vertical lines joined with the horizontal lines precisely. The most common error was drawing lines which were not ruled.

(ii) Some candidates correctly suggested that the reason for the percentage of resistant bacteria being higher for ampicillin than for imipenem was that ampicillin had been in use for a longer time, allowing more time for random mutations for antibiotic resistance (selection of resistant bacteria). Other candidates gained credit for stating that imipenem was relatively new and so has not been used very often.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells or shading and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the correct section of the leaf. Many candidates gained credit for showing details of the layer above the vascular bundle and showing subdivision of the vascular bundle. Most candidates used a label line and label to correctly identify the cuticle.

(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. Many candidates were able to draw each cell touching at least one of the other cells and with double lines representing the cell walls. The most common error was to draw lines that did not meet up precisely. Most candidates used a label line and label to show the cell wall of one cell.

(b) Some candidates annotated **Fig. 2.2** to describe three observable differences between the leaf section in **Fig. 2.2** and on **J1**. The most common answers were: in **Fig. 2.2** there were larger cells beneath the vascular bundle than on **J1**; in **Fig. 2.2** the shape of the epidermis had no ridges while there were ridges on **J1**; and in **Fig. 2.2** there was a thicker epidermis than on **J1**.

(c) Many candidates used the calibration of the eyepiece graticule scale to calculate the actual width of the midrib by counting 82 eyepiece graticule divisions across the width of the midrib, showing the number of eyepiece graticule divisions multiplied by 13.7 μm and stating the correct answer with the appropriate units.

BIOLOGY

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 so that they develop the skills that can be applied to the requirements of the examination.

Candidates should be aware that the command word in the question indicates how the candidate should respond. The word 'explain' may imply reasoning or some reference to theory, depending on the context. It is another way of asking candidates to 'give reasons for'. For example, in **Question 1(a)(iv)**, the question states 'explain the trend in your results', so the candidate needs to make sure that they give reasons as to why something happens, such as referring to increased formation of enzyme-substrate complexes leading to the removal of unwanted colour.

General comments

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

Comments on specific questions

Section A

Question 1

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

(ii) The majority of candidates organised their results clearly by presenting a ruled table. Stronger candidates included the heading for the independent variable as percentage concentration of enzyme and the intensity of colour for the dependent variable. Most candidates recorded readings for all the enzyme concentrations using symbols. Many candidates correctly recorded results which showed that the higher the percentage concentration of enzyme solution the less intense the blue colour.

(iii) Many candidates stated the correct concentration of enzyme solution that removed the colour most effectively according to their results.

(iv) Some candidates correctly stated that more enzyme-substrate complexes were formed at higher concentrations of the enzyme.

(v) Some candidates correctly stated that pH was a variable that needed to be controlled.

(vi) Some candidates correctly stated that the tests could be carried out individually to remove the error that the 2% enzyme solution was left longer than the other test-tubes. Many candidates correctly identified two other sources of error, such as the temperature was difficult to control and the colour

was difficult to judge. Many candidates correctly described improvements such as using a thermostatically controlled water-bath and using a colorimeter.

(b) (i) Most candidates used the headings given in the table to correctly label the *x*-axis (including the labels for type of sugar: glucose, fructose, sucrose, fresh and dried) and the *y*-axis (sugar content / g per 100 g of grapes). Some candidates, however, labelled the incorrect axis or gave incomplete headings. Most candidates drew bars of equal width and distance apart on the *x*-axis, used a scale of 5 to 2 cm for the *y*-axis and plotted each bar accurately. The stronger candidates drew ruled lines for the bars so that the vertical lines joined with the horizontal lines precisely. The most common error was drawing lines which were not ruled.

(ii) Some candidates correctly calculated the percentage increase in the concentration of glucose in dried grapes by subtracting 6.5 from 27, dividing by 6.5 and multiplying by 100. The majority of candidates showed their working.

(iii) Many candidates correctly suggested that the reason why the glucose concentration was higher in the dried grapes than in the fresh grapes was that the dried grapes contained less water.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells or shading and used most of the space provided. Stronger candidates gained credit for carefully following the instructions and drawing the correct section of the stem. Many candidates gained credit for drawing at least five layers of tissue and showed the correct shape and proportion of the outer layer of the stem in relation to the depth. Most candidates used a label line and label to correctly identify the epidermis.

(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. Many candidates were able to draw a large vessel element with three small adjacent cells touching the vessel element and at least one of the other smaller cells. Most candidates drew double lines to represent the cell walls. The most common error was to draw lines that did not meet up precisely. Most candidates used a label line and label to show the cell wall of one cell.

(b) Many candidates listed at least three observable differences between the section on **K1** and the section in **Fig. 2.2**, such as the epidermis was not intact on **K1** but was complete in **Fig. 2.2**, that the vascular tissue on **K1** was close to the epidermis but the vascular tissue in **Fig. 2.2** was located towards the centre of the root and the cortex on **K1** was relatively narrow while the cortex in **Fig. 2.2** was relatively wide.

(c) Many candidates used the calibration of the eyepiece graticule scale to calculate the actual diameter of the section in **Fig. 2.3** by stating that there were 78 eyepiece graticule divisions across the diameter of the root, multiplying this number by 67.0 μm and stating the correct answer of 5.23 mm.

BIOLOGY

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 so that they develop the skills that can be applied to the requirements of the examination.

Candidates should be aware that command word of the question indicates how the candidate should respond. The word 'explain' may imply reasoning or some reference to theory, depending on the context. It is another way of asking candidates to 'give reasons for'. In **Question 1(a)(v)**, which stated 'explain the difference between your results for **P2** and **Q2**', the candidate needed to make sure that they gave reasons as to how and why something happened, such as referring to the higher temperature in **Q2** which increased kinetic energy so there was a faster rate of diffusion.

General comments

In general, many candidates demonstrated that they had a good understanding of the skills required. There was good discrimination candidates and the majority 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 10% reducing sugar, showing the correct concentration below each beaker (1.0%, 0.1%, 0.01% and 0.001%) and transferring 1 cm^3 of the previous concentration to the next beaker and adding 9 cm^3 of distilled water to each beaker. A few candidates showed different volumes of 10% reducing sugar below each beaker made by proportional dilution.

(ii) The majority of candidates organised their results clearly by presenting a ruled table and including the heading for percentage concentration of reducing sugar and the heading for time and seconds. The majority of candidates gained credit for recording the times for all the concentrations of reducing sugar. Most candidates correctly recorded results which showed that the time for the higher concentration of reducing sugar was shorter than the time for the lower concentration of reducing sugar. Most candidates recorded the times in seconds and as whole numbers.

(iii) The majority of candidates correctly recorded the times for **P2** and **Q2** in seconds. A few candidates incorrectly recorded the time for **P2** shorter than the time for **Q2**.

(iv) Most candidates correctly estimated the concentrations of reducing sugar in **P2** and **Q2**.

(v) Most candidates correctly identified **Q2** as the sample containing the highest concentration of reducing sugar. Some candidates explained that as **Q2** was at a higher temperature than **P2**, the diffusion of reducing sugar from the dialysis tubing had been faster. Some explained that as **Q2** was at a higher temperature than **P2**, the molecules of reducing sugar had gained kinetic energy. Few candidates explained that as **Q2** was at a higher temperature than **P2**, the molecules of reducing sugar had gained kinetic energy which led to the faster diffusion of reducing sugar from the dialysis tubing.

(vi) Many responses correctly stated 'time to first colour change' as the dependent variable. The most common error was stating the 'diffusion of reducing sugar'.

(vii) Many answers correctly stated that one source of error was the difficulty in identifying the first colour change. A few candidates suggested that an improvement is to use a piece of white card behind the beaker so that the colour could be seen clearly. Some candidates stated as an error that the reducing sugar solutions and Benedict's reagent were not mixed equally, and a few candidates suggested the improvement of how to mix the solutions and that this should be done for a set period of time.

(viii) The majority of candidates gained credit for their suggestions. Most suggested using concentrations with narrower intervals and the strongest candidates suggested suitable concentrations to use around their estimates for **P2** and **Q2**. Many responses suggested repeating the whole experiment and calculating mean values. Many also suggested plotting a graph and reading off the values for **P2** and **Q2**.

(b) The majority of candidates drew the graph, using the headings given in the table to correctly label concentration of hydrochloric acid / mol dm^{-3} on the *x*-axis and distance acid diffused in 2 minutes / mm on the *y*-axis. Most candidates used scales of 0.2 to 2 cm for the *x*-axis and 2 mm to 2 cm for the *y*-axis, plotted the points exactly with a small cross or dot in a circle and drew a sharp, clear ruled line accurately connecting the points. The most common errors were labelling the incorrect axis, using a non-linear scale for the *x*-axis and extrapolating the line to 0.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells or shading and used most of the space provided. Most candidates gained credit for carefully following the instructions and drawing the whole of the plant organ. The stronger candidates gained credit for drawing at least three layers of tissue and showing the correct position of the vascular tissue. Many candidates used a label line and label to correctly identify the layer containing xylem.

(ii) Some candidates correctly identified the plant organ as a stem and gave the reason that the vascular tissue was in a ring.

(iii) 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. Most candidates were able to draw a group of two epidermal cells and two adjacent cells from the layer under the epidermis with double lines representing the cell walls. The stronger candidates showed the different shapes of the cells. Most candidates used a label line and label to show the cell wall of one cell. The most common errors were to draw lines that did not meet up precisely and to draw rectangular cells.

(b) The majority of candidates listed at least two differences between the section of the plant organ on **L1** and the section of the plant organ in **Fig. 2.1** using only observable differences. Most candidates stated that there were trichomes present on **L1** which were not present in **Fig. 2.1** and that **L1** had a hollow centre whereas the centre of **Fig. 2.1** contained cells. The stronger candidates stated that the vascular tissue was present in a continuous layer around the section on **L1** but was present as distinct vascular bundles in **Fig. 2.1**.

(c) (i) Many candidates correctly described counting squares that were covered by half or more than half of the area of the vascular bundle labelled **A** or the total area of the plant organ section, as 1 cm^2. The most common error was to describe only counting squares that were more than half full.

(ii) Many candidates correctly counted and recorded the area of the vascular bundle labelled **A** and the total area of the plant organ section.

(iii) The majority of responses were given credit for correctly showing the division of the area of the vascular bundle labelled **A** by the total area of the plant organ section.

BIOLOGY

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 so that they develop the skills that can be applied to the requirements of the examination.

When drawing graphs, candidates should be encouraged to choose a scale where both axes use most of the grid available and allow the graph to be read easily to half a 2 mm square. They should be aware that for some graphs, the most appropriate scale for plots to be within half a 2 mm square may be one that does not start at zero.

General comments

In general, many candidates demonstrated that they had a good understanding of the skills required. There was good discrimination between candidates and the majority 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 3.0% hydrogen peroxide, showing the correct concentration below each beaker (1.5%, 0.75%, 0.375% and 0.1875%) 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 showed different volumes of 3.0% hydrogen peroxide below each beaker made by proportional dilution.

(ii) The majority of candidates organised their results clearly by presenting a ruled table and included the heading for percentage concentration of hydrogen peroxide and the heading for number of bubbles. Most candidates gained credit for recording the number of bubbles for all the concentrations of hydrogen peroxide. Most candidates correctly recorded results which showed that the number of bubbles for the higher concentration of hydrogen peroxide was greater than the number of bubbles for the lower concentration of hydrogen peroxide. The majority of candidates recorded the results as whole numbers.

(iii) Most candidates correctly recorded the number of bubbles for **U**.

(iv) The majority of candidates correctly estimated the concentration of **U** using their results.

(v) The majority of candidates correctly suggested that measuring the volume of oxygen by counting the number of bubbles released was a source of error because the size of the bubbles varied.

(vi) Credit was awarded to many candidates who correctly suggested using a gas syringe to collect the volume of oxygen released. Some candidates suggested the use of water displacement using an upturned measuring cylinder over water to collect the volume of oxygen released.

(vii) Many responses correctly described how to modify the procedure to investigate the effect of changing pH on the number of bubbles of oxygen produced. Some candidates correctly suggested

using five different pH buffers. Some candidates correctly suggested keeping the concentration of hydrogen peroxide constant.

(b) (i) The majority of candidates successfully drew the graph using the headings given in the table to correctly label temperature / °C on the *x*-axis and activity of enzyme / au on the *y*-axis. The stronger candidates used scales of 10 to 2 cm for the *x*-axis, starting at 10 °C, and 2 to 2 cm for the *y*-axis. Many candidates also plotted the points exactly with a small cross or dot in a circle and drew a sharp, clear ruled line accurately connecting the points. The most common error was using a non-linear scale for the *x*-axis.

(ii) The majority of candidates found the correct value for enzyme activity from their graph.

(iii) Most candidates explained that after 37.5 °C the enzyme became denatured. Many candidates explained that the active site changed shape so that the substrate was no longer complementary to the active site and fewer enzyme-substrate complexes were formed.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells or shading and used most of the space provided. Most candidates gained credit for carefully following the instructions and drawing the whole of the stem. The strongest candidates gained credit for drawing at least two layers of tissue and showing the correct position and arrangement of the vascular tissue. Many candidates used a label line and label to correctly identify the epidermis.

(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. Most candidates were able to draw a group of four adjacent cells from the central tissue, with each cell touching at least two of the other cells and with double lines representing the cell walls. The most common error was drawing lines that did not meet up precisely. Most candidates used a label line and label to show the cell wall of one cell.

(b) The majority of candidates listed at least two differences between the section of the stem on **M1** and the section of the stem in **Fig. 2.1** using only observable differences. Most candidates stated that **M1** had a wavy outline while the outline of **Fig. 2.1** was circular and that **M1** had a thin epidermis whereas the epidermis of **Fig. 2.1** was thick. The stronger candidates stated that the vascular tissue was joined together on **M1** but separate vascular bundles were present in **Fig. 2.1**.

(c) (i) Many candidates correctly described counting squares that were covered by half or more than half of the area of the vascular bundle labelled **A** or the area of vascular bundle labelled **B**, as 1cm^2. The most common error was to describe only counting squares that were more than half full.

(ii) Many candidates correctly counted and recorded the area of the vascular bundle labelled **A** and the area of the vascular bundle labelled **B**.

(iii) Credit was awarded to the majority of candidates for correctly showing the division of the area of the vascular bundle labelled **A** by the area of the vascular bundle labelled **B**.

BIOLOGY

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 so that they develop the skills that can be applied to the requirements of the examination.

Candidates should be aware that the command word in the question indicates how the candidate should respond. The word 'explain' may imply reasoning or some reference to theory, depending on the context. It is another way of asking candidates to 'give reasons for'. When the question states 'suggest an explanation for your answer' the candidate needs to make sure that they give reasons as to why something happens. For example, in **Question 1(b)(iii)**, the population of *C. heintzii* would grow the fastest as the glucose uptake in *C. heintzii* was higher than the glucose uptake in *E. coli*. This was because the higher amount of glucose taken in was used for metabolic processes and increased division.

General comments

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

Comments on specific questions

Section A

Question 1

(a) (i) Many candidates were able to carry out a serial dilution of the 10.0% catalase solution, showing the correct concentration below each beaker (5.0%, 2.5%, 1.25% and 0.625%) and transferring 10 cm^3 of the previous concentration to the next beaker and adding 10 cm^3 of distilled water to each beaker.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for the independent variable as percentage concentration of catalase, and height of foam / mm for the dependent variable. Most candidates recorded heights of foam for all the enzyme concentrations. Many candidates correctly recorded results which showed that the higher the percentage concentration of catalase solution the greater the height of the foam.

(iii) Many candidates correctly recorded the height of foam for **F1** and for **F2** with the appropriate units.

(iv) Some candidates correctly estimated the concentration of catalase in the food samples **F1** and **F2** according to their results.

(v) Some candidates correctly suggested an improvement to the procedure by describing the use of a gas syringe to measure the volume of gas or by describing apparatus that used water displacement.

(vi) The majority of candidates suggested that the reason for using a 0.0% concentration in the investigation was to act as a control to show that it was the enzyme that was breaking down the hydrogen peroxide.

(vii) Some candidates correctly described how the procedure could be modified to obtain more accurate estimates of the concentrations of **F1** and **F2** by using more intermediate concentrations of catalase solutions or to plot a graph and read off the values for **F1** and **F2**.

(b) (i) The majority of candidates drew the graph using the headings glucose concentration / mg dm^{-3} on the *x*-axis and glucose uptake rate / mg min^{-1} on the *y*-axis. The strongest candidates used scales of 20 to 2 cm for the *x*-axis and 1 to 2 cm for the *y*-axis, plotted the points exactly with a small cross or dot in a circle and drew a sharp, clear ruled line accurately connecting the points. The most common errors were not including the correct label for each axis, omitting the units for both the *x*-axis and the *y*-axis and not labelling the scale every 2 cm.

(ii) Some candidates correctly suggested that glucose was transported into bacterial cells by facilitated diffusion and that glucose uptake was in direct proportion to the glucose concentration of the solution.

(iii) Some candidates correctly suggested that the glucose uptake in *C. heintzii* was higher than the glucose uptake of *E. coli* at 40 mg dm^{-3} and suggested that this was because there was more glucose available to provide energy for division of the cells.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells or shading and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the correct section of the leaf. Many candidates gained credit for drawing the tissues above and below the vascular bundle. Most candidates used a label line and label to correctly identify the 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. Many candidates were able to draw one large vessel element and three adjacent smaller cells, with double lines representing the cell walls. The most common error was to draw lines that did not meet up precisely. Most candidates used a label line and label to show the cell wall of one cell.

(b) (i) Many candidates correctly used **Fig. 2.2** to estimate the total number of stomata on the leaf by converting the total surface area from cm^2 to mm^2, dividing this figure by 0.04 and multiplying by 4 (the number of stomata shown in **Fig. 2.2**), to obtain an answer of 200 000.

(ii) Many candidates correctly stated that one other way to improve the accuracy of the estimate of the total number of stomata on a leaf was to use more fields of view.

(iii) Many candidates listed at least three observable differences between the leaf surface in **Fig. 2.2** and the leaf surface in **Fig. 2.3**. For example, the guard cell nuclei in **Fig. 2.2** were not visible but they were visible in **Fig. 2.3**, that the chloroplasts in the guard cells in **Fig. 2.2** were visible while in **Fig. 2.3** they were not visible, and the nuclei in the leaf cells in **Fig. 2.2** were not visible while the nuclei were visible in **Fig. 2.3**.

BIOLOGY

Paper 9700/41
A Level Structured Questions

Key messages

- It is important that candidates check they have understood the meaning of the question. **Question 10(b)**, for example, was sometimes misinterpreted.
- Candidates need to read plotted points on graphs to the nearest half-square and check the scale carefully; the *y*-axis scale on **Fig. 1.1** was sometimes misjudged, for example.
- The distinction between ions or atoms must be made clear, for example, hydrogen ions and potassium ions in stomatal opening in **Question 9(a)** and sodium ions and potassium ions in action potential transmission in **Question 10(a)**, but hydrogen atoms or combinations of protons and electrons attaching to NAD in **Question 6(d)**.

General comments

Candidates throughout the ability range showed a high level of knowledge and understanding on this paper. Candidates approached some challenging new contexts in the light of their previous knowledge and showed they could apply their learning to novel situations and to data presented in a variety of ways. The most common errors concerned a lack of appreciation of historical timescales in **Question 3(b)** and little awareness of balancing the rights and responsibilities of individuals in society in **Question 4(b)(iii)**.

Comments on specific questions

Section A

Question 1

(a) Candidates could usually identify the efferent blood vessel as **B** on **Fig. 1.1** and the part of the nephron where podocyte cells are located as **C**. The majority of candidates put a single letter in each of the four boxes, instead of listing the two required for the parts of the nephron that respond to ADH (**F** and **G**, the distal convoluted tubule and collecting duct) and the two parts containing cells that are located in the medulla (**E** and **G**, the loop of Henle and the collecting duct).

(b) Strong answers explained the purpose of many mitochondria, microvilli and tight junctions and the different transport proteins present on the luminal membrane and on the basal membrane of a proximal convoluted tubule cell. Weaker responses described how the proximal convoluted tubule carries out selective reabsorption, instead of the ways in which the proximal convoluted tubule is adapted to carry out this process, as asked. Some common errors were writing 'villi' or 'cilia' for microvilli, and 'basement membrane' for basal membrane. Some answers confused the ion movement mechanisms at the two membranes, or did not specify in which direction substances were moving (e.g. into the cell or into the tissue fluid or blood).

(c) (i) Well-prepared candidates could describe the trend of the sloping section of the line on **Fig. 1.2**, starting with the change in the *x*-axis variable ('As the water potential increases…') and then stating what happens to the dependent variable plotted on the *y*-axis ('…the concentration of ADH decreases'). Some candidates used the formula 'The higher the *x*-axis variable, the lower the *y*-axis variable' which was also creditworthy. Answers that suggested that the *x*-axis variable

depended upon change in the *y*-axis variable were not credited. Candidates who drew attention to the plateau in ADH concentration between 0 and +10 percentage change in water potential needed to provide these figures. Some candidates read coordinates from graphs inaccurately, for example reading the 14.8 arbitrary units at –20 percentage change in water potential as 14.4, or gave approximations, such as 'roughly 15'. Accurate readings were required for credit to be awarded.

(ii) Correct answers related to overall systemic effects, i.e. blood volume or blood pressure decreasing. Many answers discussed the effects of insufficient ADH on the water potential of the blood.

Question 2

(a) (i) The graph in **Fig. 2.1** provided many points of difference and similarity for candidates to comment on. For example, the differences in optimum temperature and maximum rubisco activase activity in the two plants, the ability of the cotton enzyme to work in a higher temperature than the false flax enzyme, and the relative activity of the two enzymes at temperatures lower than 30 °C and at temperatures higher than 30 °C. One of the commonest errors seen was the tendency of candidates to assume that the graph had time on the *x*-axis, and that the lowest temperature of 20 °C was the 'initial' or 'starting' temperature, or was a temperature 'before' 30 °C with higher temperatures being 'after' 30 °C. Candidates needed to use language appropriate to the variable they were describing, in this case 'below 30 °C' and 'above 30 °C'.

(ii) Some candidates repeated or summarised the differences seen in **Fig. 2.1** rather than offering explanations for them. The commonest correct answer was stating that cotton is adapted to live or does live in hotter parts of the world. A few stronger answers went on to explain the differently adapted enzymes in terms of differences in the genes coding for them or in the primary or tertiary structure of the enzymes.

(b) This question about how the Calvin cycle would be affected when rubisco denatures required candidates to think about what normally happens in the Calvin cycle and then to frame an answer explaining that less or none of the usual processes would occur. Weaker responses described the Calvin cycle without saying that certain steps would not happen or would happen to a lesser extent. Some candidates missed out by predicting the effect on molecules derived from the first useful product of the Calvin cycle (such as lipids and proteins) without naming the first product itself as glucose or hexose.

(c) Many candidates showed familiarity with the techniques of genetic engineering and needed to go on to use the information given in **Question 2** in greater detail, by naming the gene for rubisco activase as the desired gene for transfer and stating that the version found in cotton should be used and inserted into another crop plant.

Question 3

(a) Responses often showed some acquaintance with ecological survey techniques and in many cases this needed to be extended to the details of how to apply them in the field. The most frequent correct answers referred to random sampling, Simpson's index of biodiversity and the combination of counting species and finding their population sizes to assess overall biodiversity of a habitat. Errors included misnaming quadrats as 'quadrants' and not indicating what sort of species can be measured using quadrats, such as plants and stationary organisms. Similarly, some responses referred to the mark-release-recapture technique without explaining that this is suitable for measuring motile animal species populations. There were some references to Spearman's rank testing, which was not relevant here.

(b) Some answers made full use of the data in **Table 3.1** and correctly argued that historic climate change, hunting by humans and the introduction of alien species were factors that had a negative impact on biodiversity in Great Britain. They correctly linked individual factors to the extinction of the arctic fox (climate change) and lynx (hunting) and explained how introduced species can impact food webs and habitats by preying on native species, competing with them or spreading disease to them.

Weaker responses claimed that the extinction of coypu by conservation culling was a negative factor, whereas in fact this extinction was deliberately achieved to protect habitats and food webs from this invasive alien species. One notable error was the tendency of candidates to see the

words 'climate change' and link this to human activities. The table shows that the period of climate change in Great Britain that caused the local extinction of the arctic fox occurred well before the warming associated with human activity.

(c) Many candidates drew on their knowledge and used their imagination to describe the factors that would need to be considered when reintroducing a species like the lynx to its former habitat. The suitability of the former habitat, abundance of prey and need to ban hunting were the commonest creditworthy responses. Thoughtful responses considered the source of the introduced animals, such as from captive breeding programmes in zoos, and the need to guard against inbreeding depression in a small population. Unrealistic answers argued that the lynx should not disrupt the food web, which would be impossible. It is these effects on the food web that provide the rationale for introducing former top predators to their natural environments.

Question 4

(a) (i) Most candidates explained that PCR amplifies DNA and many pointed out that the quantity of DNA recovered from a crime scene may be too small initially for investigative tests to be performed.

(ii) This straightforward question was well-answered. Most candidates knew that smaller DNA fragments move faster or further on an electrophoresis gel, and many explained that it is because DNA fragments are negatively charged that they move across the gel towards the anode and so get spread out and separated, producing the banding pattern. It was insufficient to state that the distance travelled depended on the size of the fragments without elaborating which travelled further (small or large fragments).

(b) (i) Many responses correctly stated that the GEDmatch database is very large, larger than the far more limited police databases of DNA profiles. Particularly thoughtful answers considered how the police database (criminal suspects) differed from the public database (people with no reason to hide their DNA) and explained that the GEDmatch search gave multiple leads to perpetrators who may have taken good care to hide their DNA from the police.

(ii) Candidates showed knowledge and understanding of the term bioinformatics and most linked GEDmatch to its ability to store and analyse DNA data on a computer. Some weaker answers referred to BLAST and protein sequences; these needed to address the specific context of this question rather than rely on remembered information.

(iii) Candidates were asked to comment on the social and ethical issues raised by the first successful conviction where the open access DNA sharing website GEDmatch was used to identify a criminal (forensic genealogy). The word 'issues' was interpreted by many as meaning they needed to give a negative argument or a problem. Issues may also be positive and advantageous, so should be interpreted as neutral, inviting both negative and positive points for discussion if appropriate. The commonest non-scoring answer was 'breach of privacy' without specifying whose privacy had been breached. Candidates who explained that sharing personal data also necessarily shares the data of relatives without their consent gained credit. Thoughtful candidates realised that the increase in people who uploaded DNA to GEDmatch meant that responsible citizens wanted to play their part by helping to catch criminals to make society safer. Some answers also made sensible comments about the deterrent effect of the improved biotechnological forensic technique in reducing future crime. DNA profiling distinguishes all individuals except identical twins so wrongful convictions are not an issue and the technique can allow innocent suspects to be cleared.

Question 5

(a) Many candidates correctly identified the embryo as the site of gibberellin synthesis in a germinating barley seed. The commonest wrong answer was endosperm.

(b) (i) Many candidates stated the relationship between changing water potential and the germination index correctly, but some then contradicted themselves by calling it a negative relationship. In this case, as the *x*-variable increases, so does the *y*-variable, showing a positive correlation. Candidates scored credit for quoting figures for a pair of points accurately, but some missed out due to omitting the units MPa for water potential, or for omitting the minus sign for the negative water potentials.

(ii) Strong candidates successfully explained the relationship shown on **Fig. 5.1** as being due to a negative water potential decreasing water uptake into the seed, and water being needed to stimulate the production of gibberellin. A few candidates went on to explain that water is also needed in a germinating seed as a reactant in hydrolysis reactions, as a medium for reactions, or to create turgor pressure to expand the root and shoot.

(c) Many candidates identified the site of production of the enzyme as the aleurone layer, with most naming the enzyme amylase as an example of an enzyme produced, though maltase and protease were also acceptable answers.

(d) (i) Many candidates suggested an advantage of growing a short-stemmed variety of a flowering plant. The main error was where candidates did not adapt their knowledge to the question context of a plant grown for its flowers, and instead wrote about more energy being available for grain or fruits.

(ii) Combining knowledge of the roles of the *Le*/*le* pair of alleles and gibberellin in controlling the height of a plant stem was a challenge for many candidates. Some knew only about the *Le* allele coding for an enzyme in the gibberellin synthesis pathway, while others knew about the binding of active gibberellin to DELLA proteins to break them down and release PIF. A few candidates put all these ideas together and also realised that PIF would cause transcription of genes involved in stem growth. Candidates who had not noted the question context wrote that PIF would cause transcription of genes important in seed germination. Some candidates had difficulty using the terms gene, allele, homozygous and heterozygous correctly, and only a few stated that dwarf plants are homozygous for the recessive *le* allele, or that tall plants have the genotype *LeLe* or *Lele*.

Question 6

(a) The vast majority of candidates recognised that molecule **Y** was carbon dioxide. Wrong answers included ATP, FAD and glucose.

(b) Answers often showed some knowledge of the meaning of the term oxidation, for instance referring to loss of electrons, but many did not apply this knowledge to the context of the glycolysis section of **Fig. 6.1**. The only relevant information shown on the diagram in the steps leading to pyruvate was the release of reduced NAD. Some candidates correctly explained that the hydrogens used to reduce the NAD had come from the dehydrogenation of triose phosphate, showing that they were looking at the glycolysis section of **Fig. 6.1**. Some candidates lost credit by also referring to reduced FAD, which is only produced in Krebs cycle and not during glycolysis.

(c) (i) Many candidates used the diagram to calculate the expected net number of ATP molecules synthesised for each molecule of glucose respired as 38. The commonest errors were forgetting to subtract the 2 ATP used in glycolysis, giving an incorrect total of 40, and forgetting to add the 4 ATP from substrate level phosphorylation, giving an incorrect total of 34.

(ii) The commonest answer to gain credit was the loss of some energy from the electron transport chain in the form of heat. Candidates also mentioned the use of ATP or reduced NAD for other processes, such as energy used to transport pyruvate and reduced NAD into the mitochondrion.

(d) Many responses showed knowledge of the roles of NAD and FAD in aerobic respiration. Most candidates knew that NAD and FAD carry hydrogens from glycolysis, the link reaction or Krebs cycle to the electron transport chain. The entity carried can be described as H, an H atom, or a combination of protons and electrons. Strong responses named NAD and FAD as coenzymes and stated that they help dehydrogenase enzymes. Errors made included writing about NAD and FAD picking up H but not releasing it, i.e. not carrying it from one reaction to another, and stating that the carriers take either protons or electrons to the cristae, but not both together as is actually the case.

(e) Candidates answered this question really well. They applied their knowledge of the events of the electron transport chain to a situation where the passage of electrons stops, and explained that there would be less or no energy release, chemiosmosis, proton gradient or ATP synthesis.

Question 7

(a) Candidates mainly answered confidently on the effects of gene mutation on enzyme function. Some wrote incorrectly about substitution, insertion or deletion of a gene but most specified that these point mutations concern one or a few bases or nucleotides. Consequent changes in reading frame (frameshift) and gain or loss of stop codons were well described, though a handful of answers wrongly suggested that a base substitution could cause a frameshift. The effect on the function of iduronate 2-sulfatase was less fully described, with comments on changed primary sequence or tertiary protein structure rarely leading to a description of the complex molecules no longer being able to bind to the active site of the enzyme.

(b) For credit to be awarded, candidates needed to give a key explaining the symbols they were using. The symbol for the **X** chromosome was given in the question so the focus for the candidate needed to be in choosing a pair of letters with the capital letter denoting the normal allele (dominant) and the lowercase letter denoting the Hunter syndrome allele (recessive, as stated in the question). In the cross itself the **X** and **Y** chromosomes of the male needed to be shown, with the single copy of the normal allele shown on the **X** and no corresponding allele on the **Y** chromosome. Some candidates did not show the sex chromosomes or did not link them to the sexes of the offspring phenotypes, i.e. they did not set out the cross to show that the inheritance of Hunter syndrome is sex-linked. Some candidates confused probability with ratio, writing 3:1 instead of 1 in 4, 0.25 or 25%.

Question 8

Responses were generally very good and made use of the map and introductory information to embed the main events of allopatric speciation in the context given. Most candidates named the Great Central Valley as the geographical barrier during migration of the populations and correct references to cessation of gene flow, different selection pressures, natural selection and the development of different phenotypic features as a result of changes to the separated gene pools were frequent. A common error was the idea that a change in environment caused an appropriate mutation that enabled the salamander to cope, rather than that mutations are spontaneous random changes that may or may not be beneficial. Another significant error was the confusion of directional natural selection with the undirected and unrelated process of random genetic drift.

Section B

Question 9

(a) Many candidates achieved full credit for describing the mechanism of stomatal opening by guard cells. The active transport of hydrogen ions out of the guard cell leading to influx of potassium ions was generally well described, as were the effects on water potential, osmosis and turgor pressure. Some candidates needed to refer to ions and provide charge symbols for H^+ and K^+. A few weaker candidates confused the guard cell with the stoma or pore itself. Candidates should take care not to add irrelevant material to their answers; in this case the conditions that cause stomatal opening, for example.

(b) This question required an account of how the anatomy and physiology of the leaves of C4 plants help to maximise carbon dioxide fixation at high temperatures. It was well answered, with most candidates showing a good understanding of how separating the Calvin cycle from photophosphorylation prevents rubisco reacting with oxygen instead of carbon dioxide. Most stated that restricting oxygen from reaching rubisco and RuBP in the bundle sheath cells prevented photorespiration. A small minority confused bundle sheath cells with vascular bundle cells, but most noted that a ring of mesophyll cells separated the bundle sheath cells from air and hence oxygen. Many then described how PEP carboxylase fixes carbon dioxide into oxaloacetate in the mesophyll cells. How this carbon dioxide then gets into the bundle sheath cells to be re-fixed by rubisco with RuBP caused some confusion for weaker candidates. The oxaloacetate is converted to malate, which is able to enter the bundle sheath cells and release its carbon dioxide there when it is decarboxylated to give pyruvate. Most answers were well structured, logically arranged and used the correct scientific terms.

Question 10

(a) The topic of transmission of an action potential in a myelinated neurone provided an opportunity for strong candidates to gain maximum credit. Careful responses described the ion movements during a single action potential, with related opening and closing of ion channels, and then went on to describe saltatory conduction where local circuits are set up between adjacent nodes of Ranvier. The effects of unidirectional transmission (due to hyperpolarisation) and faster transmission (due to the separation of the action potentials at the nodes) were sometimes commented on. Weaker candidates needed to add charge symbols to Na^+ and K^+ or referred to sodium and potassium without mentioning ions. Credit for depolarisation and repolarisation was lost when candidates omitted to refer to the membrane being the part affected. In terms of ion movements, Na^+ moves into the axon cytoplasm at the start of an action potential, not into the phospholipid bilayer of the membrane as some candidates stated. The question did not ask candidates to explain how resting potential is set up, so writing about this used up valuable time. Some candidates confused the Na^+/K^+ pumps that actively transport sodium ions out of the cell and potassium ions into the cell with the voltage-gated ion channels responsible for the rapid changes in membrane potential that constitute the action potential. The vague term 'signal' was not acceptable to refer to an action potential or impulse.

(b) Most candidates correctly defined homeostasis. Some wrote at length about how the three factors are controlled, with irrelevant references to insulin, diabetes, the kidney and temperature control mechanisms. Candidates who were focused on the importance of controlling the factors were generally successful in linking the different effects of high and low temperature on enzyme activity. Many explained that water potential must be regulated to stop cells shrinking or bursting as a result of osmosis. The effect of a lack of glucose on energy release from respiration was commented on more often than the effects of high blood glucose concentration on osmosis of water from cells.

BIOLOGY

Paper 9700/42
A Level Structured Questions

Key messages

- Candidates should always use the correct spellings of scientific terms (e.g. tyrosine), and be aware that such terminology needs to be unambiguous to be rewarded.
- Some candidates were unsure of the independent and dependent variables when asked to describe a graph. For example, in **Question 1(c)(i)**, some stated that the renal arterial blood pressure was dependent on the GFR.

General comments

The examination allowed candidates to convey knowledge, articulate ideas and effectively analyse data. Novel contexts in questions were accessible to able candidates and there seemed to be no pressure of time. The wide range of marks showed a good discrimination between abilities.

Comments on specific questions

Section A

Question 1

(a) Many candidates were able to match each feature of Bowman's capsule with the correct letter from the diagram. Weaker candidates found it difficult to identify the basement membrane or where the glomerular filtrate should be. Only rarely did a candidate achieve no credit.

(b) There were many good accounts of how the structures in the Bowman's capsule and its associated blood vessels are adapted for ultrafiltration. More able candidates understood that the difference in diameters of the afferent and efferent arterioles would generate the high hydrostatic pressure necessary to force plasma and solutes from the glomerulus into Bowman's capsule. They frequently continued to describe the passage of solutes through the fenestrations between the capillary endothelial cells across the basement membrane and through the filtration slits of the podocytes. While many recognised that the basement membrane acts as a filter, some confused blood cells with large molecules or quoted an incorrect critical relative molecular mass. Less able candidates lost credit by providing insufficient detail of the capillary endothelium or podocytes, not stating that the high blood pressure would be in the glomerulus, or stating that the blood pressure would simply increase.

Weaker candidates often confused ultrafiltration with selective reabsorption in the proximal convoluted tubules and described microvilli on epithelial cells or tight junctions. The positions of the afferent and efferent arterioles relative to the glomerulus were also occasionally reversed.

(c) (i) There were many excellent descriptions of the graph provided, combining the two principal aspects of an overall increase in GFR with increasing renal arterial blood pressure alongside the plateau that could be clearly observed. Several candidates were unsure of the independent and dependent variables when presented with the data, believing that the renal arterial blood pressure was dependent on the GFR.

(ii) There were several suggestions as to why the GFR might decrease, most commonly low blood pressure, kidney damage or dehydration. Many candidates stated a decrease in blood pressure, rather than low blood pressure, which was not quite sufficient to gain credit.

Question 2

(a) Most candidates were able to state a suitable example of a human activity that contributes to the increase in atmospheric carbon dioxide concentration. The most frequent correct answer was burning or combustion of fossil fuels, followed by references to industrialisation and transport. A few candidates made vague references to burning waste or pollution.

(b) Most answers correctly restricted comments to a description of the data, rather than attempting an explanation. Many stated that the genetically modified culture had a higher dry mass, and a minority stated that this was true throughout the 14 days. Less successful answers concentrated on the end values.

The majority of responses provided a paired data quote with units. A significant number of candidates lost credit through inaccurate reading of the graph and many omitted units or gave incorrect units.

Relatively few candidates commented on the greater rate of increase in the dry mass of the GM culture compared with the non-GM culture.

(c) It was clear that many candidates knew the Calvin cycle well and could therefore access most of the credit on this question, usually appreciating the need for comparative statements. The majority of candidates recognised that an increase in concentration of rubisco would lead to more fixation of carbon dioxide and therefore an increased rate of the Calvin Cycle. Stronger candidates were able to describe the effect on GP production, TP production and RuBP regeneration.

Weaker candidates often gained limited credit for stating that the Calvin Cycle would be faster. There were very few references to carbon fixation being a rate limiting step or the concentration of rubisco being a limiting factor. A few candidates confused the Calvin cycle with the light dependent reaction and referred to increases in ATP production and reduced NADP production instead. A minority confused the Calvin cycle with the Krebs cycle.

(d) Most candidates correctly named two or three organic molecules and their uses. Common correct answers were glucose for respiration, starch for storage and amino acids for protein synthesis. The most common error was to give the uses of the intermediate products rather than the organic molecules.

(e) This question was not always well answered, with many candidates finding it difficult to balance how the use of *C. vulgaris* might compare with using trees to reduce global atmospheric carbon dioxide concentration. A wide range of suitable answers were accepted, such as the greater growth (or reproductive) rate of the alga, or the avoidance of using large areas of land (not just 'space') by planting trees. There were very few answers relating to being able to culture *C. vulgaris* in the laboratory or that it would be cheaper to set up.

Question 3

(a) Strong candidates mentioned that, when water enters the seed, the embryo will produce gibberellin which will then migrate to the aleurone layer. The fact that gibberellin would bind to a receptor which would then lead to the destruction of DELLA proteins was muddled by many, who often said that gibberellin destroyed DELLA itself. When attempted, the genetic aspects were often incomplete as many candidates did not refer to the gene coding for amylase or mRNA. Transcription of mRNA / amylase was commonly seen.

(b) (i) Although many correctly named endosperm as the location of starch reserves in a seed, some thought that starch was stored in the chloroplasts, roots or leaves.

(ii) Many candidates answered this question well. Strong responses described that the activity of the amylase increased as time went by, and that consequently the percentage of starch reserves reduced, due to amylase breaking down starch. The main issue that led to weaker responses was

the presence of two *y*-axes; some candidates used the wrong units and values for amylase and starch and so could not score credit for reference to data.

(c) (i) The majority of candidates knew that at temperatures above 50 °C the enzyme was denatured leading to a change in the tertiary structure and the shape of the active site. This would mean that the substrate, starch, would not fit the active site and there would be no enzyme-substrate complexes formed. Few mentioned that drying would reduce the synthesis of gibberellin.

(ii) Despite the question explaining that the sugars formed by the malting process would be used for beer production, a large minority did not make the link to the requirement to maintain sugar levels in this product.

Question 4

(a) (i) This question asked for an outline of a very well-known method used in genome analysis. Good responses stated that single-stranded DNA was obtained, tagged with fluorescent dyes and added to probes in the microarray. The DNA would bind or hybridise with complementary probes and the unbound DNA washed off. The chip could then be viewed under UV light to indicate the presence of genes. Some candidates spent time unnecessarily explaining different methods of getting DNA and often did not make it clear that the DNA was single-stranded. Double-stranded DNA would not hybridise with the probes. A few incorrectly described gel electrophoresis.

(ii) Candidates showed awareness of the use of bioinformatics and there were many good responses. The most common correct answers were that it stored a large amount of data using computer software and that it was fast, accurate and efficient.

(b) (i) A majority of candidates were able to carefully analyse **Fig. 4.1** and indicate that chromosomes 1 and 6 contained SNPs that have a high level of association with rheumatoid arthritis and type 1 diabetes.

(ii) There were many good attempts at comparing the genetic basis of the three diseases. The fact that the X chromosome was not involved was mentioned by many and that rheumatoid arthritis and type 1 diabetes have a greater association with each other than with type 2 diabetes. Some lost credit by not referring to SNPs or genes.

(c) Most candidates answered this question well with the most common responses being that early treatment could be started, that it would affect family planning issues and that there would be stress or worry involved. Some mentioned the cost and needed to go on to say that this would mean that the test would not be available for all. Another good response was that the test results may have an impact on jobs or life insurance.

Question 5

(a) Candidates were given three photographs, each showing different levels of biodiversity. The correct answers: species, genetic and ecosystem or habitat, were rarely given. The most common incorrect answers were to write low, medium or high.

(b) (i) Very few candidates scored full credit on this question, mainly due to a lack of precision. Quadrat was often misspelled and there were many vague descriptions of the mark-release-recapture method of estimating the population size of an insect species. Higher-achieving candidates were able to show that once the quadrat had been placed, the number of species and numbers of individual plants could be counted and identified using a key. Few were able to state how insects would be captured.

(ii) A majority of candidates achieved some success here with a good number gaining full credit. There were a lot of different incorrect tests suggested in answers, including χ^2, Hardy-Weinberg and *t*-tests. Occasionally, the names of the tests themselves were mixed up.

(c) Almost all candidates discussed the positive aspects of prairie strips, usually gaining most of the credit available for recognising that reduced fertiliser requirements were good economically. Some were able to mention that as there would be less of a loss of phosphorus and nitrogen compounds, there would be a greater yield.

Question 6

(a) (i) This question was about the properties of ATP and not its role. While many candidates gave excellent, well-focused answers, others were unable to provide any correct and relevant statements. This was sometimes due to a lack of specific language. For example, some answers referred to ATP 'producing' energy, or stated that it was soluble (without specifying water-soluble) or that it could be easily transferred 'around the body', rather than within a cell.

(ii) A range of correct statements was seen here, including the need for energy to form peptide bonds, the synthesis of mRNA or moving mRNA from the nucleus to a ribosome. Imprecise language sometimes prevented the candidate from gaining credit. For example, 'transcription of mRNA' is not correct, as it is DNA that is transcribed to produce mRNA. Some responses were limited to stating that energy is needed for protein synthesis and that ATP is a source of energy. Very few candidates referred to unwinding DNA or activating nucleotides.

(b) (i) This was answered reasonably well. A significant minority of candidates were not able to correctly identify all three letters. The site of the Krebs cycle was often erroneously identified as the inner mitochondrial membrane.

(ii) This was very well answered, many candidates scoring full credit with an answer of 12.68 - 12.7. Virtually all candidates carefully showed their working, substituting the numbers into the equation provided. Some made the error of not dividing the value given for the diameter of the mitochondrion by two to give the radius. Another frequent mistake was not squaring the radius in the first part of the formula. There were some problems with incorrect rounding of the answer.

(iii) For full credit, candidates were required to explain the effects of the large numbers of cristae, and how this relates to the needs of cardiac muscle cells. Many candidates gave good answers, identifying how the large number of cristae would provide, for example, more surface for the electron transport chain, ATP synthases or faster ATP synthesis. Some also referred to the constant contraction and relaxation of cardiac muscles.

Question 7

(a) Higher-achieving candidates understood that during melanin production tyrosinase would catalyse the conversion of tyrosine to DOPA, and then dopaquinone, although some suggested that tyrosine would be broken down during the reaction. Most then added that dopaquinone would be converted into melanin. The strongest responses mentioned that these reactions would take place within the melanosomes of melanocyte cells. A number of weaker responses gave the allele combinations that would be required for black fur without providing any detail of the biosynthetic pathway.

(b) (i) Well-prepared candidates performed the correct dihybrid cross between a black heterozygous male and a yellow female Labrador, identifying the parental genotypes and gametes and then using a Punnet square to determine all possible F1 genotypes and their respective phenotypes. Some of those who did not use a Punnet square and simply listed the six possible genotypes occasionally made an error when stating the ratio of the three phenotypes. Credit was also lost for omitting to link the phenotypes with their genotypes, or the ratio.

Some candidates incorrectly showed gametes with alleles of a single gene (**Bb** or **Ee**) rather one allele of each, while some gametes simply had a single allele. Others just used the alleles of the *MC1R* gene and ignored those of the *TYRP1* gene completely. On a few occasions, gametes were linked to sex chromosomes or co-dominant notation was used.

(ii) Many candidates named transcription factor as a protein that would be involved in the control of gene expression in eukaryotes, although some confused eukaryotes with prokaryotes and referred to repressor proteins. Others erroneously suggested regulatory genes.

Question 8

Explanations as to why Atlantic Porkfish and Pacific Porkfish can no longer interbreed successfully were variable, although the vast majority of candidates recognised that this was an example of allopatric speciation. Many candidates also understood that the formation of new land constituted a geographical

barrier, although relatively few commented that the separation of the two populations of Porkfish would prevent any further interbreeding or gene flow between them. Stronger candidates then went on to add that each population would be subjected to different selection pressures and different mutations, and that this would lead to different alleles being selected for, changing each gene pool. While some appreciated that there would be changes in morphological, physiological or behavioural features, culminating in reproductive isolation, few mentioned that this would only arise after a long period of time.

Section B

Question 9

(a) There were some excellent answers here, with succinct and entirely correct descriptions of the mechanism by which the water potential of the blood is controlled. A lack of precision caused some candidates to miss out on credit. For example, some stated that ADH is produced in the pituitary gland, without specifying the posterior pituitary or that ADH is secreted into the blood. Common errors included not specifying when the cell surface membrane was involved or not using the correct water potential terminology. Some candidates needed to identify that the membrane or cell of the collecting duct became more permeable to water. Reabsorption of water was often stated as being into the body rather than into the blood.

Many answers could have been greatly improved if the candidate had thought carefully about the points they wished to make before beginning to write. In some cases, the entire answer was written as one very long sentence. Breaking up the description into separate sentences, and also the use of paragraphs, can result in much clearer communication and can also help the candidate to clarify their thoughts and focus their writing more sharply.

(b) Many candidates could have improved their response by making use of a labelled diagram to provide this description of structure. Most were able to gain some credit with statements about myelination, nodes of Ranvier and the nucleus in the cell body. As in **Question 9(a)**, a lack of precision frequently meant that credit was missed. For example, candidates mentioned mitochondria, RER or an axon without giving details that there are many mitochondria or large amounts of RER or a long axon. Fewer candidates commented on the position of the cell body in the CNS or made correct reference to axon terminals. Some candidates confused the motor neurone with the sensory neurone. Others gave unnecessary information about the function of the various parts; saltatory conduction was given by many candidates, for example.

Question 10

(a) Candidates found this first part easier and most managed to accrue some credit for explaining how a dipstick is used to test for glucose in a urine sample. Most started by stating that the dipstick contains two enzymes, glucose oxidase and peroxidase, and that the former would initiate the process by catalysing the conversion of glucose into gluconolactone and hydrogen peroxide. Most then continued to describe the reaction of hydrogen peroxide with the chromogen also present on the stick, resulting in a colour change or the development of a brown colour. Many recognised that the colour could then be compared with a colour chart to give an estimation of the glucose concentration in the urine, and that a higher glucose concentration would result in a darker, or more intense, colour.

Few responses mentioned that the dipstick should be first dipped in urine or that the enzymes are immobilised on the strip. However, some appreciated that the glucose concentration determined by the stick was not an indication of the glucose concentration in the blood or commented that the test was semi-quantitative in nature.

(b) Candidates struggled to explain the control of gibberellin synthesis. Although some appreciated that the dominant allele was necessary for the production of active gibberellin (GA), very few mentioned that the allele coded for the functional enzyme required for this process. Stronger candidates understood that GA would bind to a receptor complex associated with an enzyme that would then bring about the destruction of the DELLA protein, and that this would allow the transcription factor PIF to bind to the promotor and initiate transcription of the genes involved in growth. It was rare for candidates to mention that in the absence of GA, the DELLA protein would inhibit PIF, preventing transcription. Some candidates repeated the answer they had given to **Question 3(a)**, describing the mechanism involved in amylase synthesis.

Some candidates omitted the first half of this question and simply outlined how gibberellin stimulates stem elongation. Many commented on the pumping of hydrogen ions into the cell wall, thereby loosening it, often including detail of the role of potassium ions in lowering the water potential of the cell to establish a water potential gradient. While some then went on to state that water would enter the cell, they did not always link this to cell expansion. More able candidates understood that this would result in cell elongation, and consequently an increase in the internode length, and some went on to mention the importance of expansins and/or auxins in this mechanism.

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Paper 9700/43
A Level Structured Questions

Key messages

- It is important that candidates check they have understood the meaning of the question. **Question 10(b)**, for example, was sometimes misinterpreted.
- Candidates need to read plotted points on graphs to the nearest half-square and check the scale carefully; the *y*-axis scale on **Fig. 1.1** was sometimes misjudged, for example.
- The distinction between ions or atoms must be made clear, for example, hydrogen ions and potassium ions in stomatal opening in **Question 9(a)** and sodium ions and potassium ions in action potential transmission in **Question 10(a)**, but hydrogen atoms or combinations of protons and electrons attaching to NAD in **Question 6(d)**.

General comments

Candidates throughout the ability range showed a high level of knowledge and understanding on this paper. Candidates approached some challenging new contexts in the light of their previous knowledge and showed they could apply their learning to novel situations and to data presented in a variety of ways. The most common errors concerned a lack of appreciation of historical timescales in **Question 3(b)** and little awareness of balancing the rights and responsibilities of individuals in society in **Question 4(b)(iii)**.

Comments on specific questions

Section A

Question 1

(a) Candidates could usually identify the efferent blood vessel as **B** on **Fig. 1.1** and the part of the nephron where podocyte cells are located as **C**. The majority of candidates put a single letter in each of the four boxes, instead of listing the two required for the parts of the nephron that respond to ADH (**F** and **G**, the distal convoluted tubule and collecting duct) and the two parts containing cells that are located in the medulla (**E** and **G**, the loop of Henle and the collecting duct).

(b) Strong answers explained the purpose of many mitochondria, microvilli and tight junctions and the different transport proteins present on the luminal membrane and on the basal membrane of a proximal convoluted tubule cell. Weaker responses described how the proximal convoluted tubule carries out selective reabsorption, instead of the ways in which the proximal convoluted tubule is adapted to carry out this process, as asked. Some common errors were writing 'villi' or 'cilia' for microvilli, and 'basement membrane' for basal membrane. Some answers confused the ion movement mechanisms at the two membranes, or did not specify in which direction substances were moving (e.g. into the cell or into the tissue fluid or blood).

(c) (i) Well-prepared candidates could describe the trend of the sloping section of the line on **Fig. 1.2**, starting with the change in the *x*-axis variable ('As the water potential increases…') and then stating what happens to the dependent variable plotted on the *y*-axis ('…the concentration of ADH decreases'). Some candidates used the formula 'The higher the *x*-axis variable, the lower the *y*-axis variable' which was also creditworthy. Answers that suggested that the *x*-axis variable

depended upon change in the *y*-axis variable were not credited. Candidates who drew attention to the plateau in ADH concentration between 0 and +10 percentage change in water potential needed to provide these figures. Some candidates read coordinates from graphs inaccurately, for example reading the 14.8 arbitrary units at –20 percentage change in water potential as 14.4, or gave approximations, such as 'roughly 15'. Accurate readings were required for credit to be awarded.

(ii) Correct answers related to overall systemic effects, i.e. blood volume or blood pressure decreasing. Many answers discussed the effects of insufficient ADH on the water potential of the blood.

Question 2

(a) (i) The graph in **Fig. 2.1** provided many points of difference and similarity for candidates to comment on. For example, the differences in optimum temperature and maximum rubisco activase activity in the two plants, the ability of the cotton enzyme to work in a higher temperature than the false flax enzyme, and the relative activity of the two enzymes at temperatures lower than 30 °C and at temperatures higher than 30 °C. One of the commonest errors seen was the tendency of candidates to assume that the graph had time on the *x*-axis, and that the lowest temperature of 20 °C was the 'initial' or 'starting' temperature, or was a temperature 'before' 30 °C with higher temperatures being 'after' 30 °C. Candidates needed to use language appropriate to the variable they were describing, in this case 'below 30 °C' and 'above 30 °C'.

(ii) Some candidates repeated or summarised the differences seen in **Fig. 2.1** rather than offering explanations for them. The commonest correct answer was stating that cotton is adapted to live or does live in hotter parts of the world. A few stronger answers went on to explain the differently adapted enzymes in terms of differences in the genes coding for them or in the primary or tertiary structure of the enzymes.

(b) This question about how the Calvin cycle would be affected when rubisco denatures required candidates to think about what normally happens in the Calvin cycle and then to frame an answer explaining that less or none of the usual processes would occur. Weaker responses described the Calvin cycle without saying that certain steps would not happen or would happen to a lesser extent. Some candidates missed out by predicting the effect on molecules derived from the first useful product of the Calvin cycle (such as lipids and proteins) without naming the first product itself as glucose or hexose.

(c) Many candidates showed familiarity with the techniques of genetic engineering and needed to go on to use the information given in **Question 2** in greater detail, by naming the gene for rubisco activase as the desired gene for transfer and stating that the version found in cotton should be used and inserted into another crop plant.

Question 3

(a) Responses often showed some acquaintance with ecological survey techniques and in many cases this needed to be extended to the details of how to apply them in the field. The most frequent correct answers referred to random sampling, Simpson's index of biodiversity and the combination of counting species and finding their population sizes to assess overall biodiversity of a habitat. Errors included misnaming quadrats as 'quadrants' and not indicating what sort of species can be measured using quadrats, such as plants and stationary organisms. Similarly, some responses referred to the mark-release-recapture technique without explaining that this is suitable for measuring motile animal species populations. There were some references to Spearman's rank testing, which was not relevant here.

(b) Some answers made full use of the data in **Table 3.1** and correctly argued that historic climate change, hunting by humans and the introduction of alien species were factors that had a negative impact on biodiversity in Great Britain. They correctly linked individual factors to the extinction of the arctic fox (climate change) and lynx (hunting) and explained how introduced species can impact food webs and habitats by preying on native species, competing with them or spreading disease to them.

Weaker responses claimed that the extinction of coypu by conservation culling was a negative factor, whereas in fact this extinction was deliberately achieved to protect habitats and food webs from this invasive alien species. One notable error was the tendency of candidates to see the

words 'climate change' and link this to human activities. The table shows that the period of climate change in Great Britain that caused the local extinction of the arctic fox occurred well before the warming associated with human activity.

(c) Many candidates drew on their knowledge and used their imagination to describe the factors that would need to be considered when reintroducing a species like the lynx to its former habitat. The suitability of the former habitat, abundance of prey and need to ban hunting were the commonest creditworthy responses. Thoughtful responses considered the source of the introduced animals, such as from captive breeding programmes in zoos, and the need to guard against inbreeding depression in a small population. Unrealistic answers argued that the lynx should not disrupt the food web, which would be impossible. It is these effects on the food web that provide the rationale for introducing former top predators to their natural environments.

Question 4

(a) (i) Most candidates explained that PCR amplifies DNA and many pointed out that the quantity of DNA recovered from a crime scene may be too small initially for investigative tests to be performed.

(ii) This straightforward question was well-answered. Most candidates knew that smaller DNA fragments move faster or further on an electrophoresis gel, and many explained that it is because DNA fragments are negatively charged that they move across the gel towards the anode and so get spread out and separated, producing the banding pattern. It was insufficient to state that the distance travelled depended on the size of the fragments without elaborating which travelled further (small or large fragments).

(b) (i) Many responses correctly stated that the GEDmatch database is very large, larger than the far more limited police databases of DNA profiles. Particularly thoughtful answers considered how the police database (criminal suspects) differed from the public database (people with no reason to hide their DNA) and explained that the GEDmatch search gave multiple leads to perpetrators who may have taken good care to hide their DNA from the police.

(ii) Candidates showed knowledge and understanding of the term bioinformatics and most linked GEDmatch to its ability to store and analyse DNA data on a computer. Some weaker answers referred to BLAST and protein sequences; these needed to address the specific context of this question rather than rely on remembered information.

(iii) Candidates were asked to comment on the social and ethical issues raised by the first successful conviction where the open access DNA sharing website GEDmatch was used to identify a criminal (forensic genealogy). The word 'issues' was interpreted by many as meaning they needed to give a negative argument or a problem. Issues may also be positive and advantageous, so should be interpreted as neutral, inviting both negative and positive points for discussion if appropriate. The commonest non-scoring answer was 'breach of privacy' without specifying whose privacy had been breached. Candidates who explained that sharing personal data also necessarily shares the data of relatives without their consent gained credit. Thoughtful candidates realised that the increase in people who uploaded DNA to GEDmatch meant that responsible citizens wanted to play their part by helping to catch criminals to make society safer. Some answers also made sensible comments about the deterrent effect of the improved biotechnological forensic technique in reducing future crime. DNA profiling distinguishes all individuals except identical twins so wrongful convictions are not an issue and the technique can allow innocent suspects to be cleared.

Question 5

(a) Many candidates correctly identified the embryo as the site of gibberellin synthesis in a germinating barley seed. The commonest wrong answer was endosperm.

(b) (i) Many candidates stated the relationship between changing water potential and the germination index correctly, but some then contradicted themselves by calling it a negative relationship. In this case, as the *x*-variable increases, so does the *y*-variable, showing a positive correlation. Candidates scored credit for quoting figures for a pair of points accurately, but some missed out due to omitting the units MPa for water potential, or for omitting the minus sign for the negative water potentials.

(ii) Strong candidates successfully explained the relationship shown on **Fig. 5.1** as being due to a negative water potential decreasing water uptake into the seed, and water being needed to stimulate the production of gibberellin. A few candidates went on to explain that water is also needed in a germinating seed as a reactant in hydrolysis reactions, as a medium for reactions, or to create turgor pressure to expand the root and shoot.

(c) Many candidates identified the site of production of the enzyme as the aleurone layer, with most naming the enzyme amylase as an example of an enzyme produced, though maltase and protease were also acceptable answers.

(d) (i) Many candidates suggested an advantage of growing a short-stemmed variety of a flowering plant. The main error was where candidates did not adapt their knowledge to the question context of a plant grown for its flowers, and instead wrote about more energy being available for grain or fruits.

(ii) Combining knowledge of the roles of the *Le*/*le* pair of alleles and gibberellin in controlling the height of a plant stem was a challenge for many candidates. Some knew only about the *Le* allele coding for an enzyme in the gibberellin synthesis pathway, while others knew about the binding of active gibberellin to DELLA proteins to break them down and release PIF. A few candidates put all these ideas together and also realised that PIF would cause transcription of genes involved in stem growth. Candidates who had not noted the question context wrote that PIF would cause transcription of genes important in seed germination. Some candidates had difficulty using the terms gene, allele, homozygous and heterozygous correctly, and only a few stated that dwarf plants are homozygous for the recessive *le* allele, or that tall plants have the genotype *LeLe* or *Lele*.

Question 6

(a) The vast majority of candidates recognised that molecule **Y** was carbon dioxide. Wrong answers included ATP, FAD and glucose.

(b) Answers often showed some knowledge of the meaning of the term oxidation, for instance referring to loss of electrons, but many did not apply this knowledge to the context of the glycolysis section of **Fig. 6.1**. The only relevant information shown on the diagram in the steps leading to pyruvate was the release of reduced NAD. Some candidates correctly explained that the hydrogens used to reduce the NAD had come from the dehydrogenation of triose phosphate, showing that they were looking at the glycolysis section of **Fig. 6.1**. Some candidates lost credit by also referring to reduced FAD, which is only produced in Krebs cycle and not during glycolysis.

(c) (i) Many candidates used the diagram to calculate the expected net number of ATP molecules synthesised for each molecule of glucose respired as 38. The commonest errors were forgetting to subtract the 2 ATP used in glycolysis, giving an incorrect total of 40, and forgetting to add the 4 ATP from substrate level phosphorylation, giving an incorrect total of 34.

(ii) The commonest answer to gain credit was the loss of some energy from the electron transport chain in the form of heat. Candidates also mentioned the use of ATP or reduced NAD for other processes, such as energy used to transport pyruvate and reduced NAD into the mitochondrion.

(d) Many responses showed knowledge of the roles of NAD and FAD in aerobic respiration. Most candidates knew that NAD and FAD carry hydrogens from glycolysis, the link reaction or Krebs cycle to the electron transport chain. The entity carried can be described as H, an H atom, or a combination of protons and electrons. Strong responses named NAD and FAD as coenzymes and stated that they help dehydrogenase enzymes. Errors made included writing about NAD and FAD picking up H but not releasing it, i.e. not carrying it from one reaction to another, and stating that the carriers take either protons or electrons to the cristae, but not both together as is actually the case.

(e) Candidates answered this question really well. They applied their knowledge of the events of the electron transport chain to a situation where the passage of electrons stops, and explained that there would be less or no energy release, chemiosmosis, proton gradient or ATP synthesis.

Question 7

(a) Candidates mainly answered confidently on the effects of gene mutation on enzyme function. Some wrote incorrectly about substitution, insertion or deletion of a gene but most specified that these point mutations concern one or a few bases or nucleotides. Consequent changes in reading frame (frameshift) and gain or loss of stop codons were well described, though a handful of answers wrongly suggested that a base substitution could cause a frameshift. The effect on the function of iduronate 2-sulfatase was less fully described, with comments on changed primary sequence or tertiary protein structure rarely leading to a description of the complex molecules no longer being able to bind to the active site of the enzyme.

(b) For credit to be awarded, candidates needed to give a key explaining the symbols they were using. The symbol for the **X** chromosome was given in the question so the focus for the candidate needed to be in choosing a pair of letters with the capital letter denoting the normal allele (dominant) and the lowercase letter denoting the Hunter syndrome allele (recessive, as stated in the question). In the cross itself the **X** and **Y** chromosomes of the male needed to be shown, with the single copy of the normal allele shown on the **X** and no corresponding allele on the **Y** chromosome. Some candidates did not show the sex chromosomes or did not link them to the sexes of the offspring phenotypes, i.e. they did not set out the cross to show that the inheritance of Hunter syndrome is sex-linked. Some candidates confused probability with ratio, writing 3:1 instead of 1 in 4, 0.25 or 25%.

Question 8

Responses were generally very good and made use of the map and introductory information to embed the main events of allopatric speciation in the context given. Most candidates named the Great Central Valley as the geographical barrier during migration of the populations and correct references to cessation of gene flow, different selection pressures, natural selection and the development of different phenotypic features as a result of changes to the separated gene pools were frequent. A common error was the idea that a change in environment caused an appropriate mutation that enabled the salamander to cope, rather than that mutations are spontaneous random changes that may or may not be beneficial. Another significant error was the confusion of directional natural selection with the undirected and unrelated process of random genetic drift.

Section B

Question 9

(a) Many candidates achieved full credit for describing the mechanism of stomatal opening by guard cells. The active transport of hydrogen ions out of the guard cell leading to influx of potassium ions was generally well described, as were the effects on water potential, osmosis and turgor pressure. Some candidates needed to refer to ions and provide charge symbols for H^+ and K^+. A few weaker candidates confused the guard cell with the stoma or pore itself. Candidates should take care not to add irrelevant material to their answers; in this case the conditions that cause stomatal opening, for example.

(b) This question required an account of how the anatomy and physiology of the leaves of C4 plants help to maximise carbon dioxide fixation at high temperatures. It was well answered, with most candidates showing a good understanding of how separating the Calvin cycle from photophosphorylation prevents rubisco reacting with oxygen instead of carbon dioxide. Most stated that restricting oxygen from reaching rubisco and RuBP in the bundle sheath cells prevented photorespiration. A small minority confused bundle sheath cells with vascular bundle cells, but most noted that a ring of mesophyll cells separated the bundle sheath cells from air and hence oxygen. Many then described how PEP carboxylase fixes carbon dioxide into oxaloacetate in the mesophyll cells. How this carbon dioxide then gets into the bundle sheath cells to be re-fixed by rubisco with RuBP caused some confusion for weaker candidates. The oxaloacetate is converted to malate, which is able to enter the bundle sheath cells and release its carbon dioxide there when it is decarboxylated to give pyruvate. Most answers were well structured, logically arranged and used the correct scientific terms.

Question 10

(a) The topic of transmission of an action potential in a myelinated neurone provided an opportunity for strong candidates to gain maximum credit. Careful responses described the ion movements during a single action potential, with related opening and closing of ion channels, and then went on to describe saltatory conduction where local circuits are set up between adjacent nodes of Ranvier. The effects of unidirectional transmission (due to hyperpolarisation) and faster transmission (due to the separation of the action potentials at the nodes) were sometimes commented on. Weaker candidates needed to add charge symbols to Na^+ and K^+ or referred to sodium and potassium without mentioning ions. Credit for depolarisation and repolarisation was lost when candidates omitted to refer to the membrane being the part affected. In terms of ion movements, Na^+ moves into the axon cytoplasm at the start of an action potential, not into the phospholipid bilayer of the membrane as some candidates stated. The question did not ask candidates to explain how resting potential is set up, so writing about this used up valuable time. Some candidates confused the Na^+/K^+ pumps that actively transport sodium ions out of the cell and potassium ions into the cell with the voltage-gated ion channels responsible for the rapid changes in membrane potential that constitute the action potential. The vague term 'signal' was not acceptable to refer to an action potential or impulse.

(b) Most candidates correctly defined homeostasis. Some wrote at length about how the three factors are controlled, with irrelevant references to insulin, diabetes, the kidney and temperature control mechanisms. Candidates who were focused on the importance of controlling the factors were generally successful in linking the different effects of high and low temperature on enzyme activity. Many explained that water potential must be regulated to stop cells shrinking or bursting as a result of osmosis. The effect of a lack of glucose on energy release from respiration was commented on more often than the effects of high blood glucose concentration on osmosis of water from cells.

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Paper 9700/51
Planning, Analysis and Evaluation

Key messages

- Candidates should carefully read through the whole of the paper before starting to write.
- 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.

General comments

The responses covered the whole mark range for the paper and there were many good answers indicating careful preparation.

There was no indication that candidates were short of time.

Comments on specific questions

Question 1

(a) (i) Most candidates were able to identify the independent and dependent variables correctly. Some responses for the dependent variable were too vague, e.g. writing about the 'amount' of carbon dioxide rather than the volume. It was important for candidates to remember that the dependent variable is what is actually measured, so 'the activity of yeast', which was seen on occasions, was not a creditworthy response.

(ii) Creditworthy responses needed to go beyond saying 'to mix the yeast and glucose'. The idea was to get the yeast evenly dispersed throughout the mixture. This was often explained by clearly qualifying the term 'mix' in some way such as 'to mix evenly' or by answering in terms of not letting the yeast cells form a separate layer.

(iii) Candidates often seemed familiar with this style of question and type of investigation and there were a number of well-presented planning exercises.

Most candidates suggested at least five different temperatures to use and gave a sensible range, so that the sort of temperatures likely to be near the optimum, based on their theoretical knowledge of enzyme activity, were sufficiently covered. Extreme temperatures like 0 °C or 100 °C are really outside this range and, in a practical sense, candidates would be wasting time using them. A few candidates refined the method so that once the approximate optimum was indicated, further temperatures at small intervals around this point were conducted; this gained credit. The apparatus in **Fig. 1.2** showed a basic water-bath; it was acceptable to build on this and use a more sophisticated thermostatic water-bath or keep the whole set-up in a temperature-controlled environment. Many successfully followed this route. Where candidates suggested using the beaker of water to control temperature, they should also have included checking the thermometer and adjusting the temperature as necessary.

The volume of the mixture of the yeast suspension and glucose solution needed to be standardised and their temperature needed to be equilibrated to each temperature investigated before taking any readings. Credit was also gained for the idea of using a buffer to ensure a constant pH and also for running a control experiment where the living yeast suspension was replaced by boiled yeast

suspension or water. What was recorded in the experiment needed both a time and a volume reference. Thus either 'record the volume (of CO_2) collected over a set time', or 'record the time taken to collect a set volume (of CO_2)' were both acceptable responses. Many candidates successfully suggested repeating the experiment at each temperature at least twice (i.e. three replicates) and calculating a mean. It was important to use the correct terminology here, i.e. 'mean' not 'average'. It was also important to be clear that the means must be taken for each temperature; some responses seemed to suggest that an overall mean for all the temperatures together was taken.

No investigation is totally without risk, so stating that this one involved no risks or needed no precautions did not gain credit. Whilst this is a relatively low risk investigation, yeast is a potential allergen or irritant and thus sensible precautions such as gloves and masks are relevant.

(iv) To gain full credit when asked to produce a sketch graph, candidates must pay attention to details, such as using the correct units. Most commonly, candidates correctly labelled the *y*-axis as volume of CO_2 / cm^3. Rate of CO_2 production was also credited provided the units were appropriate. The sketch graph should be a curve, not ruled lines. In this investigation the expected result would be an increase followed by a decrease, not a linear increase or an increase and then a plateau. The majority of candidates produced creditworthy sketch graphs.

(b) Candidates were not expected to know the Crabtree effect. The question provided the necessary information that needed to be read carefully and then related to the results shown in **Fig. 1.3**. The question asked for supporting evidence from the two graphs that *C. tropicalis* does not show the Crabtree effect. Many candidates were able to focus in on flask 2 as providing this evidence and, in many cases, supported this with a suitable data quote comparing CO_2 production in *S. cerevisiae* and C. *tropicalis* in that flask. Fewer were successful in concisely conveying the point that the Crabtree effect allows enhanced fermentation / anaerobic respiration for *S. cerevisiae* in the experimental conditions, so maintaining CO_2 output at much the same level as flask 1. The reduced CO_2 output in *C. tropicalis*, compared to flask 1, shows that enhanced fermentation / anaerobic respiration does not occur as shown by the lower CO_2 production – i.e. the Crabtree effect does not occur.

Question 2

(a) From the data given in **Fig. 2.2** there was no very clear trend or correlation visible and a number of candidates correctly suggested that and gained credit. Other candidates suggested that there could be a trend. As the question asked for a description, it was necessary for the response to describe the possible trend in terms of increasing latitude showing a trend of decreasing species diversity or species numbers.

(b) (i) Candidates found this question difficult to answer. Many of the responses simply listed all the information in the syllabus about when a Spearman's rank correlation test might be used rather than relating these ideas to the data and information provided in the question and focusing on these points. Good responses conveyed the idea that the data was discrete or could be ranked and that the numbers of paired observations exceeded 5. Some candidates gained credit for the idea of paired data sets. References to scatter graphs was often too generic – just saying 'a scatter graph was done to show a relationship' was not creditworthy. There needed to be the idea that 'the scatter graph suggests a possible relationship'.

(ii) The majority of candidates were able to give a clear null hypothesis, such as there being no correlation or relationship between latitude and the number of species. The commonest error was to write about there being no difference rather than no correlation. A few gave the alternative hypothesis.

(iii) Many candidates approached this question with confidence and showed a good grasp of this aspect of statistics, suggesting that they had practised analysing statistical data. Most responses correctly stated that the critical value was 0.485 (at $p = 0.05$) and thus the null hypothesis is accepted as the calculated value is lower than this. Accepting the null hypothesis means that there is no significant correlation between latitude and the number of bird species. The fact that the calculated value is not zero and has a negative sign does indicate a weak negative correlation but not a significant one. Some candidates selected the incorrect row for the critical value so lost some credit.

(c) This question asked for some discussion on the limitations of the method and data gathered in the context of the general statement in the stem of the question. No answer was expected to cover all the ideas below, and there were many good answers covering a range of ideas which were fully qualified, well expressed and gained full credit.

Data was only collected on birds and no data on actual numbers of each, but species diversity includes all types of organism, and their relative abundance has a part in assessing diversity. Many responses discussed ideas such as 'birds can fly' but sometimes in too general a way. Credit for problems with identifying all the birds in the area needed to be qualified in terms of issues such as looking similar or migrating at certain times of year. Some candidates suggested that using volunteers was a limitation. Volunteers may be very good – the key is how much training the recorders had. Only sampling once a year and in winter does not give a full idea of all the species. The latitude range was only 37–40 degrees north, so this was not a very wide range and does not include south of the equator. Less specific references to 'the whole earth not being sampled' were not credited without qualification. There is no information on how the sample sites were selected. Some responses mentioned that more seemed to be coastal. There was no indication that they were selected at random, which is a limitation.

(d) Candidates did not need to memorise the formula for the Lincoln index but there were many who did know it and used it successfully to explain their method. In the first capture, birds are caught, counted, marked and released. This was not always clearly stated, with catching or counting left out. The omission was sometimes corrected by valid information in a formula later. For the second capture it was not always clear that the total number of birds and the number of marked birds was counted. Credit was also given for some detail of the actual techniques used. The handling and marking technique must not be potentially harmful to the birds in any way and was often mentioned and credited. Alternatively, the time between the release and recapture needs to be sufficient to allow those marked to mix freely with the whole population. A few hours would not be enough and months or years too long – as breeding, death or migration would have altered the population.

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Paper 9700/52
Planning, Analysis and Evaluation

Key messages

- Candidates should read the whole question before answering.
- When planning an investigation, it is important to set out the work in a logical way and for it to be detailed enough for another student to follow.
- When planning investigations, it is not necessary to copy out all the information given in the question paper. The information provided should serve as the basis for developing the method asked for in the question.
- Candidates should read the instructions carefully, especially when asked to not repeat details given in the stem of the question, as no credit will be awarded for this.

General comments

The responses covered the full range of credit available and there was no evidence that candidates were short of time on this paper. Very few candidates left any questions unanswered.

Comments on specific questions

Question 1

(a) (i) Many candidates correctly identified the independent variable as the type of sugar supplied to the yeast. Those candidates who recalled that the dependent variable is the factor that is measured directly during an experiment gained credit for referring to the height of the gas in the test tube. Some candidates stated that the volume of gas or rate of respiration were the dependent variable. However, these cannot be measured directly and therefore did not gain credit.

(ii) Many candidates were able to correctly state that the reason the yeast suspension was stirred before dividing it into two samples, was to ensure that the yeast cells would be evenly distributed, not just mixed. Candidates should be reminded to read the procedure provided in the stem of the question, as some thought the reason for mixing was to ensure the sugar and the yeast were mixed. This was not creditworthy, as the sugar had not been added to the yeast at this stage in the procedure.

(iii) There were many clear and detailed plans which gained full credit. Less creditworthy responses tended to just copy out the basic procedure provided in the question. There were a number of candidates who spent time repeating how they would make up the yeast suspension or set up the apparatus. As stated in the question, this was not required and therefore, credit was not awarded for these details.

Many candidates were able to either state that the volumes of yeast suspension and sugar solutions would be standardised or suggested an actual volume to be used. Most of the volumes suggested were suitable for the equipment being used with only a few suggestions of 1 dm^3 yeast suspension being added to a test tube. Those candidates who referred to adding 'about' 10 cm^3 did not gain credit. It needed to be clear that the same volumes would be added each time. Candidates also needed to use the term volume, rather than amount, to gain credit here.

Most candidates included what they would measure in their plans, with some correctly suggesting the use of a ruler to measure the height of the gas in the test tube. A few responses did not gain credit as they did not refer to what they would measure or chose apparatus which was not suitable for this particular experiment.

Some candidates were able to correctly suggest the use of boiled yeast or the replacement of the yeast with water as a control. Not adding the yeast or the sugar solution alone was not correct, nor was replacing the yeast with glass beads or other non-living material.

Many responses mentioned replicating the test a suitable number of times, but this was sometimes linked to calculating an average. It is important to use the term 'mean' in scientific work and students should use this terminology as a matter of course.

Safety issues should be specific to the investigation. This investigation was low risk. Credit was given to responses which correctly identified that some people could be allergic to the yeast and should wear gloves or a mask. A few candidates just referred to being careful when handling the yeast and this was insufficient to gain credit.

(b) (i) Candidates were asked to state how the rate of respiration could be calculated from the results shown in **Fig. 1.3**. For credit they needed to either choose stated volumes of gas and corresponding times then describe how they would use them to calculate the rate, or state they would find the volume of gas collected in a particular time and divide the volume by that time. As candidates were asked to make reference to **Fig. 1.3**, credit was not awarded for just stating volume of gas divided by time. Alternative ways to gain credit were also seen and some candidates gave clear descriptions of drawing tangents to the lines and calculating the gradient.

(ii) Many candidates were able to correctly identify that the production of gas when in the presence of glucose was higher than in the presence of maltose. Some candidates just stated the volumes of gas produced when in the presence of both sugars; they needed to use comparative terms such as 'more' or 'higher' to gain credit.

It was common to see candidates referring to the rate of respiration being higher when in the presence of glucose. Some candidates were able to conclude that for maltose to be respired, it needed to be broken down first and a few candidates correctly identified that an enzyme was needed for this process to occur.

(c) Many responses correctly referred to the pH meter being a more accurate and more precise way of measuring the pH rather than using an indicator solution and colour chart. As the question was comparing the two methods, candidates needed to use comparative terms to gain credit here. Therefore, stating that the pH meter was accurate did not gain credit unless compared to the alternative method. Many candidates correctly referred to the indicator solution and colour chart method being subjective, with some gaining credit for a clear description of what they meant even if they did not use the term 'subjective'.

Question 2

(a) Candidates were asked to state one variable, other than temperature, which should be standardised while making recordings of the male gray tree frogs. It was important that candidates follow the instructions to state only one variable, rather than list many. A few candidates who listed many variables did not gain credit as they restated variables they had been already told had been controlled.

(b) The majority of candidates gained credit here. Some needed to develop their answer beyond writing that there was a negative correlation, by stating that as the temperature increased, the interval between calls decreased.

(c) (i) There were many detailed reasons provided for this question, with the vast majority of candidates attaining credit for referring to the data being paired, the data being continuous or the data showing a normal distribution. A few candidates contradicted themselves by also stating that the data was discrete or discontinuous so were unable to gain credit. Some of the best responses referred to the scatter diagram suggesting a linear correlation.

(ii) Most candidates were able to correctly state a null hypothesis. Some referred to there being no difference between the temperature and the intervals between calls, rather than no correlation and so did not attain credit. The null hypothesis must match the statistical test being used.

(iii) Candidates who correctly identified that 50 pairs of measurements were used were able to choose the correct critical values from the table. Some candidates were confused about which statistical test was being used and attempted to calculate degrees of freedom which led to them choosing the incorrect critical value. The negative Pearson's correlation coefficient, ***r***, of –0.717, caused some candidates to state that the calculated value was less that the critical value. This was incorrect, as the negative symbol simply indicates that the correlation is negative. Candidates should be aware that when comparing the calculated value with the critical value in a correlation question, the negative symbol should be ignored.

(d) Many candidates were able to describe features of the mating call shown in **Fig. 2.4** which the scientist could also study. The sound frequency of the pulses, the duration of each call and the number of pulses within each call were all commonly seen. A few candidates suggested features which could not be observed in **Fig. 2.4** and did not gain credit. Some candidates misinterpreted the question and gave descriptions of the data collected rather than the features which could also be studied.

(e) Most candidates gave detailed descriptions about the importance of leaving the frogs for sufficient time between the first and the second capture to allow mixing of the population. Others described in detail how to mark the frogs and explained the reason why they chose that particular marking technique. Many candidates could describe how the mark-release-recapture method could be used to estimate a population of frogs very well and gained full credit for this question. Some candidates needed to develop their answer by stating that the number of frogs caught in the first capture would be counted and others needed to include a key when they quoted the Lincoln Index to gain credit.

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