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Paper 9700/11
Multiple Choice

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

General comments

The paper differentiated well. Candidates found questions **7**, **13**, **16** and **35** the most straightforward. Questions **1**, **2**, **6**, **12**, **14**, **17**, **24**, **26** and **33** were the most challenging.

Comments on specific questions

Question 2

Most candidates were unable to use the information correctly to determine the actual length of the nucleus. Options **A** and **D** were the most common incorrect responses. Candidates selecting these options may have incorrectly converted the number of divisions of a stage micrometre scale to an appropriate length.

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Question 5

More than a fifth of all candidates could use the information to obtain the correct answer.

Questions 9 and 10

Only a third of all candidates correctly answered these questions .

Question 14

Most candidates found this question difficult to interpret. However, the concentration of empty active sites would be high at the start and end of the reaction.

Question 16

Over four fifths of all candidates answered this correctly showing a good understanding of the processes involved in transport into and out of a cell.

Question 18

A fifth of all candidates incorrectly thought that each chromosome only has one telomere. Nearly half of candidates incorrectly thought that each chromosome had four telomeres.

Question 20

Candidates found this question challenging and chose each option equally, showing that stages of mitosis were not well understood.

Question 22

Nearly half of all candidates correctly used the information provided to answer correctly. Nearly half of all candidates chose option **B**.

Question 30

Almost half of all candidates were able to use the information and obtain the correct sequence.

Question 34

Three quarters of all candidates correctly identified the curve for normal lung function and of these candidates about two thirds correctly identified the other two curves.

Questions 36 and 38

Most candidates were unable to answer these questions correctly.

Question 37

Almost half of all candidates correctly used the information to conclude that the cell walls of species X are chemically different from those of bacteria.

Question 39

Two thirds of all candidates were unable to use the information and obtain the correct sequence.

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Paper 9700/12
Multiple Choice

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

General comments

The paper differentiated well. Candidates found questions **1, 11, 14, 33 and 36** the most straightforward. Questions **12**, **13**, **15**, **32**, **34** and **40** were the most challenging.

Comments on specific questions

Question 2

More than half the candidates were able to calculate the actual length of the virus. Option **A** was the most common incorrect response. Candidates selecting this option may have converted the measurement into micrometres rather than nanometres as stated in the question.

Question 3

Almost half of all candidates were able to state that the structure shown (centriole) contains protein only. Option **C** was the most common incorrect response with candidates thinking that the centrioles also contain phospholipids.

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Question 5

Nearly half of all candidates answered this correctly. The most common incorrect response was option **C**. The key knowledge these candidates had not considered was that a plant cell contains both mitochondria and chloroplasts with circular DNA.

Question 7

Nearly half of all candidates answered this correctly. Option **D** was the most common incorrect answer chosen. Candidates needed to consider that if the enzyme was boiled it would be denatured so no reducing sugar would be produced.

Question 9

Nearly half of all candidates answered this correctly. Option **B** was the most common incorrect answer chosen. The key knowledge that candidates did not realise was that hydrogen bonding in the tertiary structure of proteins occurs between the R groups.

Question 13

Less than a third of all candidates were able to select the correct option. Many candidates incorrectly selected an option including statement 1 and over a half of all candidates incorrectly selected an option including statement 3 suggesting that this syllabus area may be less well understood.

Question 21

Whilst the majority of all candidates correctly selected an option containing DNA, just over half of these candidates knew that it was a sequence of nucleotides.

Question 24

Two fifths of candidates were able to answer this question correctly. Option **D** was the most common incorrect answer chosen. Candidates needed to consider that mass flow does not only occur in plants.

Question 27

The majority of candidates incorrectly selected option **A**. The key knowledge the candidates needed to consider was the difference between the terms cardiac cycle and a circuit of the body.

Question 29

Whilst the majority of candidates understood that the first two factors affect blood pressure, many candidates did not realise that the third factor also affects blood pressure.

Question 32

This question was only answered correctly by a third of all candidates. Nearly three quarters of all candidates incorrectly chose an option that included endothelium as being present in the bronchioles.

Question 34

This question was only answered correctly by a third of all candidates. The most common incorrect answer chosen was option **C**.

Question 37

Nearly half of all candidates answered this correctly. Whilst the majority of all candidates knew that statements 1 and 2 were correct, candidates also thought statement 4 was correct.

Question 40

Option **A** was the most common incorrect response with over half of all candidates choosing this. The majority of candidates were unable to use their knowledge of the immune system in an unfamiliar situation.

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Paper 9700/13
Multiple Choice

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

General comments

The paper differentiated well. Candidates found questions **2**, **19**, **21**, **22**, **25**, **32**, **34** and **35** the most straightforward. Questions **7**, **16**, **20**, **38** and **39** were the most challenging.

Comments on specific questions

Question 3

Over half of all candidates answered this correctly. The most commonly chosen incorrect response was option **A** with candidates not identifying the presence of mitochondria or plasmodesmata in the electron micrograph and incorrectly thinking the cell contained chloroplasts.

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Question 7

Over half of all candidates were able to answer this question correctly. However nearly half of candidates incorrectly chose option **A** with candidates thinking that both reducing sugars and non-reducing sugars **must** be present.

Question 8

More than half of all candidates were able to answer this question correctly. The majority of high-endorsing candidates answered this correctly, whilst the low-endorsing candidates selected each option almost equally.

Question 9

Over half of all candidates were able to answer this question correctly. However, option **B** was the most common incorrect response chosen as candidates did not recall that starch contains 1,6 glycosidic bonds.

Question 16

Half of all candidates correctly selected option **A**. However nearly half of all candidates incorrectly selected options that included osmosis. Osmosis involves the movement of water (solvent), but not movement of solute.

Question 19
Nearly all candidates were able to answer this question correctly showing an excellent understanding of parts of a chromosome and relating it to its function.

Question 20

Nearly half of all candidates chose options with feature 3. The key knowledge these candidates had not considered was that that mitosis is not important for the growth of a single-celled organism. For a single-celled organism to grow the volume of the single cell would need to increase.

Question 21 and 22
Most candidates were able to answer this question correctly showing a good understanding of the stages of the cell cycle and structure of bases.

Question 24

Over half of all candidates were able to answer this question correctly. Option A was the most commonly chosen incorrect answer with candidates unable to correctly determine the nucleotide sequence. The key knowledge these candidates had not considered was that the tRNA sequence is complementary to the mRNA sequence.

Question 36

Over half of all candidates were able to answer this question correctly. Most of the high endorsing candidates were able to correctly interpret the information in the question. However, over half of the low endorsing candidates incorrectly selected option **A**. Candidates needed to understand the term resistance and relate this to the growth of the bacteria.

Question 38
Just over a third of all candidates were able to use the information provided and decide that in order to provide a **short-term** treatment the monoclonal antibodies would target the antibodies secreted by the plasma cells.

Question 39
Nearly half of all candidates answered this question correctly and used their knowledge that the function of V (the hinge region) is to allow the antibody to fit around the antigen.

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Paper 9700/21
AS Level Structured Questions

Key messages

Candidates are advised to read carefully each question before writing their answer and to make sure they address each aspect of the question. **Question 1(a)(iii)** asked candidates to suggest the role of ATP in mitosis. Most candidates were able to link ATP to its role in providing energy but fewer went on to link this to specific energy-requiring processes that occur during mitosis, such as the movement of chromatids. **Question 6(b)(ii)** asked candidates to describe the immune response by T-lymphocytes. This meant that maximum credit was not gained by candidates who gave detail of an immune response only by B-lymphocytes.

Candidates need to be careful when describing energy. Energy cannot be produced during chemical reactions. Energy is released during respiration and ATP is produced. Candidates who wrote about the production of energy in **1(a)(ii)** where unable to gain credit.

When explaining the term double circulation in **Question 3(a)**, it was not enough to describe blood travelling to the lungs and the body. Reference needed to be made to the blood passing through the heart twice for every complete circuit of the body, or to use the terms pulmonary circulation and systemic circulation in the correct context.

General comments

Candidates should take their time to study diagrams carefully before answering a question. In **Question 1(b)**, candidates needed to apply their knowledge of the cell cycle and of mitosis to identify events occurring in **Fig. 1.2** that do not occur during mitosis. For example, it was important to identify DNA replication, which occurs during interphase in human cells, and cytokinesis which occurs after mitosis.

It is important for candidates to correctly interpret the command words used in a question stem and also to avoid giving information that is not required. For example, in **Question 2(b)(iii)**, candidates were asked to explain the results of the experiment shown in **Fig. 2.2**. A significant proportion of candidates were unable to gain credit because they described the data, stating the trends they could see, but did not explain the data. In **Question 4(b)(ii)**, candidates were required to recall the process of translocation and then summarise only the knowledge that was relevant to the question. A common mistake was to describe the process of loading sucrose into the sieve tube elements via co-transport with hydrogen ions.

Candidates will not usually gain credit from copying information already given to them. In **Question 3b(i)**, candidates were required to make use of information about the action of two antibiotics. Those candidates that simply copied the information from **Table 3.1** were unable to gain credit.

Candidates should take time to plan longer answers that require application of understanding, before they begin to write, such as in **Question 6(b)(i)**. They should refer back to the question regularly during planning and check their response to make sure that they are answering the question that has been asked. Many missed the request to answer in terms of T-lymphocytes and incorrectly focused their response on B-lymphocytes.

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Comments on specific questions

Question 1

(a) (i) This was well answered. The majority of candidates were able to use the terms chromatid and centromere effectively. The term histone was less well known and some candidates confused it with other biological terms, such as histidine.

(ii) The majority of candidates were able to correctly identify the stage of mitosis shown in **Fig. 1.1**. A small minority identified the stage as interphase, which is not a stage of mitosis.

(iii) Most candidates were able to describe the role of ATP as providing energy for the cell. Fewer were able to link this to energy-requiring processes that occur during mitosis. Some made links to chemical reactions such a DNA replication, which is a reaction that requires ATP, but were unable to gain credit because it does not occur during mitosis.

(b) This question required candidates to apply their knowledge of mitosis to an unfamiliar process occurring in bacterial cells. There were some very good answers to this question. The strongest responses indicated that the candidates had looked carefully at **Fig. 1.2** to write about processes they could see occurring, such as DNA replication and cytokinesis. Some candidates confused the question and wrote about events that only occurred during mitosis, such as sister chromatids being pulled to opposite poles of the cell, rather than events that occur only during binary fission. These candidates were not able to gain full credit as they were not answering the question asked.

Question 2

(a) (i) Correctly identifying the ester bond in **Fig. 2.1** was straightforward for many candidates. The most common incorrect answer was to include the carbon, oxygen double bond within the circle, which does not form part of the ester bond.

(ii) This question was well answered by most candidates. Those that did not gain full credit confused condensation reactions with hydrolysis reactions. Some candidates did not appreciate that three water molecules would be produced, one for each ester bond formed.

(b) (i) The majority of candidates were able to describe lipase enzymes as a macromolecule. Fewer were able to apply their understanding of the term extracellular enzyme to the description of the action of lipase and identify this as a second appropriate term. A significant number of candidates thought that lipase enzymes were fibrous proteins. Candidates should be aware that enzymes are globular proteins, having an approximately spherical shape.

(ii) Most candidates were able to gain full credit by making effective use of the data in **Fig. 2.2** to perform a suitable calculation. The most common incorrect answer was 5 hours, which resulted from an error in reading the scale on the graph.

(iii) Some candidates gained full credit for their answers to this question. The question asked candidates to explain the results, which required application of understanding of an enzyme-controlled reaction to the data provided in the question. The most common explanation that gained credit was an identification of the denaturing of the lipase enzymes, as a result of the drop in pH of the reaction mixture. The best answers also identified the slowing of the reaction due to the hydrolysis of the substrate. Some candidates correctly made reference to the production of acid during the reaction because they recognised that the pH of the reaction mixture was dropping: a few then linked this to the reaction catalysed by lipase enzymes and identified that the acids were fatty acids. The most common error was to describe the data in detail, or to describe a steep decline in the pH of the reaction mixture at the start of the experiment, followed by a plateau, but offer no biological explanation for these descriptions.

(iv) There were some very good answers to this question, in which candidates applied their understanding of factors affecting an enzyme-controlled reaction to this experiment and recognised that the decrease in pH would be more rapid. Only a few candidates gained full credit by extending their prediction to suggest an earlier plateau. Candidates should look carefully at the number of marks allocated to each question and use this to ensure they include sufficient detail in their answers.

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Question 3

(a) (i) Many candidates recognised the importance of describing the passage of the blood through the heart twice for every complete circuit of the body. As noted in **Key messages**, candidates could not be awarded credit for describing the passage of blood to the lungs and the body without reference to the heart or a complete circuit of the body.

(ii) Very few candidates were able to identify structure **A** as the chordae tendineae. Some attempted to identify the type of valve shown in **Fig. 3.1** rather than the structures labelled **A**. Some had not read the information provided in the question stem carefully enough and suggested **A** could be a named structure in the heart such as the SAN. These answers were unable to gain credit but were allowed an error carried forward mark for a correctly linked role.

(b) (i) To gain full credit for this question, candidates needed to consider the information provided in **Table 3.1** and apply their understanding of how antibiotic resistance develops to this unfamiliar context. Many candidates were able to recognise that the two antibiotics had different sites of action and that this was important in the prevention of resistance by killing all the bacteria. Fewer were able to further develop this idea to suggest that this would mean that even if resistance evolved to one antibiotic the bacteria would still be susceptible to the other. Only the best candidates made reference to mutations as the source of resistance and the need for more than one mutation to target the two different sites of action. Most candidates that gained credit recognised the importance of killing all bacteria with the antibiotics.

(ii) There were some very good descriptions of vertical and horizontal transmission to describe how the allele for resistance might increase in frequency in a bacterial population. Some candidates made reference to mutations but often did not gain credit for this because they did not describe these as random mutations, or link the mutation to the production of an allele that results in resistance to gentamicin. Some described the possible consequences of not finishing a prescribed course of antibiotics and a few discussed how an antibiotic acts as a selection pressure.

Question 4

(a) (i) A few candidates were able to identify the structures labelled **W** as plasmodesmata. Common incorrect answers included stomata and (xylem) pores. This again highlights the importance of reading the information in the question stem carefully. The candidates were provided with the information that **Fig. 4.1** was a section of a plant cell wall and that cytoplasmic strands form part of the structure in living plant tissue. This description should have allowed candidates to eliminate both stomata and (xylem) pores as a possible answer.

(ii) Most of the candidates who gained credit described movement of substances between connected cells.

(b) (i) This was a straightforward question for many candidates who were able to accurately outline the key features of a virus. A small minority confused the virus with the structure of a prokaryote cell and stated features such as flagellum.

(ii) Candidates were asked to describe the mechanism that allows assimilates and viruses to travel through the sieve tubes. Descriptions of the mechanism for transport were variable, with a proportion of candidates writing about loading into a phloem sieve tube, rather than transport through the phloem sieve tube. As part of this, a common error was to describe the process of loading sucrose into the sieve tube elements via co-transport with hydrogen ions. Many correctly described the hydrostatic pressure gradient, with stronger responses including the information that the movement of assimilates and viruses down that gradient occurred from a source to a sink and that movement is by mass flow. A few also described the process of unloading.

Question 5

(a)(i) The function of tissue **X**, cartilage, was well known by most candidates. A few candidates incorrectly identified the tissue as muscle and described the role of the muscle contracting to narrow the airway.

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(ii) This was answered well, with many candidates able to describe the C-shaped rings of cartilage in the trachea. Some candidates omitted this question. suggesting a lack of knowledge of this syllabus learning outcome.

(iii) There were some very good answers to this question, in which candidates demonstrated their understanding of the role of ciliated cells and goblets cells found in the epithelial tissue. Candidates who were unable to gain credit gave answers that lacked detail and specific biological terminology, such as describing movement of pathogens rather than movement of the mucus that traps the pathogens and describing hairs rather than cilia.

(b) (i) Most candidates recognised that the younger, smaller elephant would have a larger surface area to volume ratio. A small minority failed to gain credit, describing the volume and surface area independently rather than as a ratio.

(ii) The strongest answers applied their knowledge of surface area to volume ratio from the previous question, recognising the large volume would mean many cells, and that each of those cells would need oxygen for aerobic respiration. Some went on to consider the long diffusion distance required to provide oxygen to certain cells in the elephant, and the time that would be needed. Weaker answers discussed aerobic respiration but did not link it to the need for enough oxygen to get to every cell, or the idea of many cells all aerobically respiring. A few candidates considered the idea that the activity of the elephant would mean that the cells would have a high demand for oxygen.

(iii) Some of the responses to this question highlighted the need to make sure that the answer addressed the question asked, which was to describe the structure of a collagen molecule. Most of the responses that gained credit described a collagen molecule made up of three polypeptides forming a triple helix. Some went on to describe the hydrogen bonds that hold the three polypeptides in this structure. A few candidates mentioned glycine in their descriptions. Weaker answers simply described collagen as a fibrous protein, using information from the question stem, and did not give further information about the molecule. Others described a collagen molecule as being strong, rather than focus on the structure of the molecule. Some candidates would have benefited by checking the number of marks allocated to the question and evaluating whether their answer included enough different ideas to gain full credit. Many gave very brief responses.

(iv) Candidates had to use the information in the question stem to recognise that the collagen fibre must be very strong in order to resist the large forces produced when the elephant is standing. The strongest answers used knowledge of the structure of a collagen fibre, such as staggered ends of the molecules in the fibre, to suggest how this strength is provided.

Question 6

(a) (i) Most candidates were able to state that mutations that result in a tumour cause uncontrolled mitosis. Good responses developed this idea by outlining how this uncontrolled mitosis might have come about, such as a lack of regulation of the cell cycle. Candidates who referred to cell cycle checkpoints failing to identify the mutation, or to the involvement of genes that regulate the cell cycle (such as proto-oncogenes mutating to become oncogenes), gained credit for these ideas. Some candidates correctly described a tumour as a mass of abnormal cells produced by uncontrolled mitosis.

(ii) In order to answer this effectively, candidates needed to read the information in the question stem carefully and then apply their understanding to identify the type of mutation that would result in a change of only one amino acid. The best answers recognised that the mutation would be a substitution mutation. These answers went on to describe a change in one nucleotide in the base sequence of DNA coding for this protein. Weaker candidates confused the amino acid sequence with the nucleotide sequence, describing changes in the amino acid sequence of a DNA molecule. Very few candidates referred to a change in the DNA triplet coding for an amino acid or to a change in the mRNA codon. Weaker candidates referred to codons without linking them to mRNA.

(b) (i) Candidates needed to apply their knowledge of vaccination and how it stimulates an immune response to this unfamiliar context, which asked specifically about T-lymphocytes. Good answers described killer T-cells binding to the TSA on the tumour cell and releasing a chemical such as hydrogen peroxide to destroy the tumour cell. Candidates who simply stated that the killer T-cell destroyed the tumour cell without further explanation were unable to gain credit because they were given this information in the question stem. The majority described the humoral immune response

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and the production of antibodies, which was not required. These answers were only able to gain credit for reference to vaccination stimulating an immune response and antigen presentation.

(ii) This question was well answered, with many candidates identifying that this method of treatment would be personalised to the patient's own tumour cells and so be more effective. Most candidates were also able to state that a disadvantage would be that the immune system may not recognise the TSA as foreign because it was on self-cells from the body.

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Paper 9700/22
AS Level Structured Questions

Key messages

Antibiotics and antibodies are easily confused by many candidates. Many incorrectly describe antibiotics, rather than antibodies, as acting against antigens. Candidates would benefit from remembering that antibiotics are therapeutic drugs that act to directly kill or inhibit the growth of whole bacterial cells.

Water moves down a water potential gradient from a higher (less negative) water potential to a lower (more negative) water potential. Water potential values are measured in units of pressure. Candidates should avoid describing a higher water potential as 'a higher concentration of water molecules'.

The nucleus is an example of a eukaryotic organelle that has a double membrane. The correct term for this is the nuclear envelope rather than the nuclear membrane. The nuclear envelope is visible in electron micrographs of cells and although it cannot be seen in a photomicrograph, it should still be described as the nuclear envelope and not the nuclear membrane.

General comments

A high level of expertise in bringing together different strands of knowledge to organise a response was shown by a good proportion of the candidates. Many were careful and precise in their use of scientific terminology, particularly in the extended responses in **Questions 1(b)**, **2(a)** and **(6)(a)(ii)**. Generally, a good understanding was shown of the command words used in questions, although some candidates do not fully understand the difference between 'describe' and 'explain'.

The value of checking answers was highlighted by several questions. For example, in **Question 1(b)**, when describing and explaining events occurring between point **P** and point **Q**, some candidates used either **P** or **Q** for both locations. In **Question 1(c)**, a quick check as to whether the calculated magnification seemed reasonable may have benefited a number of candidates – in these cases they could have been prompted to start their calculation again.

Question 5(c) required candidates to consider data from two different graphs, comparing an immobilised enzyme with the same enzyme free in solution. Some were not careful with using the key provided to correctly identify the two curves. This meant that on one or on both graphs, the results were interpreted incorrectly.

Some candidates were well practised in observing features that help to identify structures in the gas exchange system. **Fig. 3.1**, showing a section through a bronchus, was used to answer **Question 3(a)** and **(b)**. In addition to using prepared microscope slides, images from websites can also be used to improve observation and interpretation skills. Some candidates had difficulty gauging relative proportions in **(b)**, identifying a structure as large as **J** as an alveolus or a capillary.

Comments on specific questions

Question 1

(a) (i) Most candidates correctly identified the described structures as plasmodesmata, and the majority knew the correct spelling for these structures. Plasmodesma (singular) was also credited. Common incorrect answers were cytoplasm and vacuole. Responses that noted plasmodesmata and vacuole or another named cell structure were not credited.

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(ii) Only responses using the terms water potential or water potential gradient were credited. Some candidates used the symbol Ψ, which was accepted. As noted in **Key messages**, concentration of water molecules is not the same as water potential. The question asked 'Explain what causes …' rather than 'Explain how ….' so those that only wrote about the movement of water from cell **B** to cell **C** by osmosis were unable to gain credit. Some began their response at the xylem, which was not necessary. Some incorrectly referred to water moving from a high water potential gradient to a low water potential gradient.

(iii) This was well known and most gained the mark. The most common incorrect answers were apoplastic, vacuolar, and cytoplasm.

(b) The strongest responses took a sequential approach to this question and produced a full account by packing all the required detail into a few concise sentences. By studying **Fig. 1.1**, four main locations between point **P** and point **Q** were identified: the cell wall of the spongy mesophyll cell, the substomatal air space, the stoma and the external atmosphere. There was some careful use of scientific terminology, for example *water vapour* was described as *diffusing* out from the *intercellular air space* through the open *stoma*. This can be compared with a weaker response, for example where *water* moves out from the *intracellular space* through *stomata* by *osmosis*. Some described the open stoma as open guard cells. Others finished the response at the stoma and did not mention the external atmosphere or **Q**. It was important to read the question carefully. Some wrote about movement of water up the xylem and across the leaf. Others described a symplastic or apoplastic pathway taken by water that took a route via all the cells to arrive at the guard cells. A number incorrectly stated that water evaporates out of the stoma or from the guard cells rather than from the cell walls of the spongy mesophyll cells. Some gave information about factors affecting transpiration, which was not a requirement of the question.

(c) The formula for calculating the magnification of an image was well known, and most were able to measure within the acceptable range. Those not gaining full credit tended to measure in cm and then multiply this directly by 1000 to get a measurement in μm, having forgotten to multiply by 10 to get mm. Some tried to convert to standard form but made errors and ended up with an unrealistic magnification.

Question 2

(a) To gain full credit for this question, candidates needed to relate the points they were making to the topic of antibiotic resistance and to show an understanding of how using more than one antibiotic to treat TB is preferable to using a single antibiotic. The responses that were descriptive rather than explanatory, tended to focus solely on the information in **Table 2.1** and repeated this in sentence form. Some of these answers did not progress to explain how bacteria would be destroyed. Better answers explained how the different modes of action of the antibiotics would prevent a reservoir of bacteria, resistant to an antibiotic, from becoming established. A common error in weaker responses was to interpret the column headed as length of treatment as the time that it takes for each antibiotic to act, or to think that the treatments were given sequentially.

(b) (i) Most gained the mark for this question. Incorrect responses included translation and protein synthesis.

(ii) Knowledge of competitive and non-competitive inhibitors needed to be applied to the information given about the action of rifampicin on RNA polymerase. Binding of rifampicin at a place other than the active site implied non-competitive inhibition and the consequential change to the shape of the active site. Binding close to the active site could also suggest a partial barrier to the entry of the substrate. A number of candidates did not think through these ideas and wrote about both types of inhibition. To gain the maximum credit, stronger responses applied knowledge of enzyme action with the events in transcription that rely on RNA polymerase and gave details about how these events would be prevented. The most common of these were to suggest that nucleotides could not be joined together and to explain that phosphodiester bond formation would not occur. It was important in this question to focus on the information that had been given and many candidates would have benefited from reading the stem several times before answering.

(c) (i) The answers for this question could be deduced using information contained in **Table 2.2**. Many found this straightforward, but there were some that did not complete the table. Others did not notice that the amino acids for mRNA codons UUC and UAC were given for strain **A** and strain **G**.

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(ii) For this question, only the column headed MIC / $\mu g\,cm^{-3}$ in **Table 2.2** was needed. Many correctly identified the four strains concerned, **B**, **D**, **F** and **G**. Others were distracted by the column headed 'number of other mutations in the specific region' and either listed the strains with three other mutations, **D**, **E**, **F** and **G**, or used this column in conjunction with MIC to give **D**, **F** and **G**.

(iii) It would have been helpful for some to return to the introduction to **(c)** to remind themselves of the mode of action of rifampicin, namely binding to RNA polymerase. This would have helped them understand that the mutation occurring in mRNA codon in positions 526 or 531 and the other mutations occurring in the specific region, would only cause changes to RNA polymerase. If binding of rifampicin becomes more difficult, a level of resistance is conferred on the bacterial cell because transcription can still proceed. Many deduced that different levels of resistances could be due to the other mutations, fewer went on to suggest explanations relating to changes in RNA polymerase. Some listed the effects of other gene mutations that resulted in antibiotic resistance, such as the production of enzymes to degrade antibiotics or efflux pumps.

Question 3

(a) The trachea and the bronchus both have cartilage as part of their structure, so it was important that candidates described the cartilage visible in the section of lung tissue in **Fig. 3.1** as irregular or as plates. This would distinguish the cartilage in bronchus from the incomplete, or C-shaped rings, found in the trachea. Smooth muscle, elastic tissue, a wide lumen and ciliated epithelium were commonly stated instead of irregular cartilage. Although these were visible in **Fig. 3.1**, they cannot be considered as the feature that would identify the gas exchange structure as the bronchus. However, they were credited as additional features. Ciliated epithelium was given as a label in **Fig. 3.1**, so candidates were expected to state features other than this. There were numerous references to goblet cells and ciliated epithelial cells and because these form ciliated epithelium, they were ignored.

(b) The photomicrograph of the section of lung tissue, showed structure **J** with a thick tunica media, and hence a narrow lumen in relation to the thickness of the wall. Some candidates correctly identified **J** as an artery or arteriole, stating one of these reasons. Flexibility was allowed in crediting a correct response in **J**, so that blood vessel or vein were also accepted. Many found this a challenging question. Those who named an acceptable structure usually went on to give a correct reason to support the identification. There were numerous incorrect suggestions. Cartilage was a common incorrect response, even though the same candidates had listed cartilage as an identifying feature of the bronchus in **(a)**. Alveolus was also frequently stated. This should have been discounted by candidates because structure **J** was different in structure and size to the many other alveoli surrounding the bronchus. Similarly, the very different relative proportions of a capillary and a bronchus should have directed candidates away from suggesting **J** as a capillary. A lack of ciliated epithelium should have allowed candidates to eliminate bronchiole as a suggestion. Red blood cell was seen as a response from some candidates, which indicates a lack of knowledge about sizes of the structures or an inability to gauge proportions.

(c) Most knew that goblet cells produced mucus to trap pathogens. Some could have been more precise in describing the involvement of cilia in moving the mucus out of the airways. Others ignored the reference to cilia in the question and wrote about hairs or finger like structures, or described ciliated epithelial cells moving. In some weak responses, 'dirt' or 'dust' was incorrectly used as an alternative term to pathogen. Candidates should also avoid referring to pathogens as 'germs'.

Question 4

(a) (i) The two most common correct features stated for this question were the nuclear envelope and the nuclear pores. Even though a double membrane was shown in **Fig. 4.1**, a relatively high proportion of candidates used the term nuclear membrane to describe the nuclear envelope and did not gain credit. Only the strongest responses gave the precise detail required regarding the location of the ribosomes on the surface of the outer nuclear membrane, or noted that the outer membrane was continuous with the rough endoplasmic reticulum. Although many read carefully the instruction to describe the extra detail of the nucleus that could be seen using the electron microscope, there were a number that thought they were being asked to describe the extra detail of the plasma cell. This meant that some correct biological detail gained no credit as it was not answering the

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question, and highlighted how essential it is to re-read the question and for a candidate to check that a written response is suitable for the posed question.

(ii) Most showed a good understanding of the limits set by a light microscope to view cell structures. Where full credit was not given, this tended to be because the response was not worded to show the relationship between the small size of the named cell structures and the limit of resolution of the microscope. For example, 'the structures are too small for the resolution of the light microscope is creditworthy, whereas a standalone sentence with 'the structures are small', is not. Some were so intent on giving much detail about the resolution of the light microscope and explaining what was meant by resolution, that they forgot to mention the cell structures. Weaker responses stated 200 μm or gave the wavelength of light as the resolution of the microscope or wrote only about magnification. Some were also confused about how the structures were too small to interfere with light waves and stated that they interfered with light wavelengths.

(b) Some candidates had a very sound knowledge of the stages in the cell cycle. The most challenging mark to gain was for knowledge of the events in the three phases of interphase. Most found it easiest to match the correct letters to prophase and telophase.

(c) Strong responses:

- made it clear whether the points being made were about the primary immune response or the secondary immune response
- explained how the secondary response differed and provided immunity to a person against an infectious disease
- used the terms disease, infection, pathogen, antigen and antibody in the correct contexts.

Others confused terms such as disease and pathogen, pathogen and antigen, antigen and antibody, infection by a pathogen and disease. Knowledgeable answers explained that in the secondary immune response, memory B-lymphocytes divide to produce cells that become plasma cells. Some thought that the cells changed into plasma cells. A common misconception was to think the more rapid secondary response was due to faster division of cells, rather than a greater number of cells as a result of the primary response.

(d) Many either stated that myasthenia gravis is an example of an autoimmune disease or explained that the disease involved the production of antibodies against self-antigens. Those not gaining credit repeated the information given or gave confused accounts that reflected a gap in knowledge. A smaller proportion gained full credit by giving further information, with some showing greater knowledge than the requirements of the syllabus.

Question 5

(a) Most could deduce from **Fig. 5.1** that reducing sugar **X** was fructose. Common incorrect answers included glucose and maltose.

(b) Most candidates gave confident answers to gain at least one of the two marks. A higher proportion of candidates explained that enzymes lower the activation energy for reactions, than explained about the formation of the enzyme-substrate complex.

(c) Many candidates noted the level of credit allocated to the question and gave appropriate detail. It was acceptable to use the data provided and point out the areas where immobilised sucrose phosphorylase or the enzyme free in solution were favoured for use in industrial reactions. Good accounts made it clear whether the points being made were about immobilised enzyme or the enzyme free in solution. These responses also gave consideration to the data in both graphs. Data that was extracted to be used to support the points made was accurate and relevant. Candidates gaining partial credit tended to focus too much on one idea and did not produce a response to a 'discuss' question. Weaker responses made errors in data extraction or made very general statements, sometimes repeating information given at the start of the question. Some gave a description of the results without making any reference to which enzyme type is better to use.

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Question 6

(a) (i) Most realised that the Bohr effect changed the oxygen dissociation curve shown in **Fig. 6.1** by shifting the curve to the right, and that the curve would be the same shape. Some of these curves did not gain credit because the curve was drawn along the *x*-axis for some distance before rising, or because the curve began to level off at a percentage saturation of haemoglobin that was far too low. There were some that did not attempt this question, despite completing the rest of **Question 6**, and this emphasises that candidates should check that they have completed every part of each question.

(ii) There were some excellent answers to this question. These generally took a sequential approach and expressed each point using scientific terminology and making it clear that the Bohr effect would produce an increase in the oxygen provided to cells for aerobic respiration. Candidates who gave a general, but a correct, account of the role of haemoglobin without considering the Bohr effect were limited to two out of the three available marks. More confused responses often included the implication that carbon dioxide took the place of oxygen bound to haemoglobin, so causing the offloading of the molecule. Some based their response within the lung and explained that an increase in carbon dioxide would cause an increase in the formation of oxyhaemoglobin. Others forgot to mention haemoglobin and only wrote about the red blood cell.

(b) Most candidates noted that the question concerned transport mechanisms across cell surface membranes. Almost all of these knew that carbon dioxide crossed the membrane by (passive/simple) diffusion. A high proportion thought that hydrogen carbonate ions were transported by active transport, rather than facilitated diffusion. This error was allowed to carry forward to the explanation section, where candidates were expected to state the nature of the substance being transported as an explanation as to why carbon dioxide crossed the phospholipid bilayer directly through the hydrophobic core and why hydrogen carbonate ions require membrane transport proteins. In this section, some did not give enough detail to be credited, but if they stated correctly the nature of the two substances, one mark could be gained. Others misread the question and repeated some of their response to **(a)(ii)**, thinking they were being asked to describe the role of haemoglobin in the carriage of respiratory gases.

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Paper 9700/23
AS Level Structured Questions

Key messages

Antibiotics and antibodies are easily confused by many candidates. In **Question 4**, many candidates described antibiotics, rather than antibodies, as acting against antigens. Candidates would benefit from remembering that antibiotics are therapeutic drugs that act by killing or inhibiting the growth of bacteria, whereas antibodies are proteins secreted by plasma cells during immune responses.

The nucleus is an example of a eukaryotic organelle that has a double membrane. The correct term for this is the nuclear envelope rather than the nuclear membrane. The nuclear envelope is visible in electron micrographs of cells and although it cannot be seen in a photomicrograph, it should still be described as the nuclear envelope and not the nuclear membrane.

Fig. 2.1 showed three cell types found in leaves. These cells were identified by letters **A**, **B** and **C**. Some candidates could have improved their answer to **Question 2(a)** by making sure that references to structures identified in diagrams were clear and accurate, using the terminology provided in the question.

General comments

Many candidates gave good answers to questions in the first part of the paper. The majority found parts of **Question 5** demanding, especially when describing the structure and function of collagen. There were examples where candidates needed to read the questions more carefully. Candidates should recognise and use correct terminology. For example, in **Question 4(b)**, lymphocytes were often described as releasing antibiotics. In this question there were often lengthy descriptions of the use of vaccines with few, if any, comparative points made with the use of antibiotics. In **Question 5(d)**, many candidates described the effect of pH on the activity of collagenase, but did not give any explanation, as required by the question. This highlights the importance of reading questions carefully and planning answers that are appropriate for the command words.

Careful use of technical terms was essential in answering many of the questions in this paper. In **Question 2(a)** it was important to refer to the names of the cells correctly. Some candidates simply referred to sieve tube elements, or sieve tubes, as ‘phloem’. In **Question 5(a)(iii)** and **(b)** there was much confusion between polypeptides, molecules, fibrils and fibres. Many could have been clearer about what they meant when they wrote ‘collagen’ and that each molecule of collagen consists of three polypeptides. In **Question 2(b)** many candidates referred to an increase in surface area or an increase in the surface area to volume ratio and then should have related this to the correct aspect of the cell they were describing.

Comments on specific questions

Question 1

(a) Many candidates correctly identified the names of the parts of the gas exchange system shown in **Fig. 1.1** and gave the appropriate letter from the diagram. Common errors were to confuse the trachea (**B**) and the bronchus (**C** or **J**). The bronchus and bronchioles were often confused with each other as the bronchioles were often identified as **J**.

(b) Many gave the correct terms to match the statements about the components of tobacco smoke. Carcinogen and mutagen were the expected answers to **A** although tar was also accepted. Names of specific carcinogens, such as benzopyrene, were not accepted. Some candidates referred to

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adrenaline causing an increase in heart rate (**E**), ignoring that the question asked for a component of tobacco smoke.

Question 2

(a) Most candidates stated a suitable function of the sieve tube element (**C** in **Fig. 2.1**) writing either translocation, or the transport of assimilates or named assimilate(s). Although it was obvious in many cases that candidates knew that the mesophyll cell (**B**) is a site of photosynthesis, they did not make this clear in their answers. In general, candidates were better at explaining how sieve tube elements are adapted for their function than explaining the adaptations of mesophyll cells. Few stated that the chloroplasts, visible in the diagram, absorb light for photosynthesis. Instead of writing about photosynthesis some wrote about transpiration, but rarely stated that mesophyll cells have large, moist surfaces where evaporation of water occurs. Common errors about the structure of sieve tube elements included stating that they have 'no organelles' and that sieve plates prevent the collapse of sieve tubes.

(b) Some candidates were successful in identifying the main advantage of the cell wall infoldings in the transfer cells (**A**). Many incorrectly stated that these infoldings increase the surface area of the *cell wall* and then correctly wrote about the functions of transport proteins in *cell membranes*. Also, credit was only given if candidates referred to the surface area to volume ratio *of the cell*. Very few made the connection that the wall infoldings require a larger surface area of cell surface membrane, hence the space for more proton pumps and co-transporter proteins. Many could have improved their response by identifying the direction of movement of the protons or sucrose molecules. There were many good accounts of the functions of these membrane proteins in companion cells, but they often just answered the question 'explain how sucrose is loaded into phloem sieve tubes from mesophyll cells' and did not address the question that was set. Candidates who thought about the order of events in the movement of sucrose often wrote clearer answers.

Question 3

(a) (i) This question asked candidates to identify the G1 and S phases of the cell cycle from a graph showing the change in DNA content in a stem cell during one cell cycle. A very high proportion of the candidates identified both phases correctly. Although DNA replication was also accepted for **B**, replication unqualified was not. Gap 1 phase was occasionally referred to as growth phase 1, which was also accepted. Some misinterpreted the graph and identified the two phases as stages of mitosis, typically metaphase and anaphase.

(ii) Many candidates gave the correct answer – telophase. The most common incorrect answer was anaphase.

(iii) Good responses to this question on preparation for cytokinesis often started with the formation of the nuclear envelope surrounding the two groups of chromosomes. Candidates also described the breakdown of the spindle apparatus and the formation of a cleavage furrow. Candidates occasionally described the role of actin microfilaments in the formation of a contractile ring and the arrangement of organelles so that they are divided equally between the daughter cells. Some candidates described all the events of mitosis, often in some detail, which were not relevant. The term nuclear membrane was not accepted as an alternative to the nuclear envelope.

(iv) A few candidates completed **Table 3.1** correctly to show the number of nuclei and number of chromosomes in each nucleus as 1, 1, 2 and 12, 12, 12. The most common error was to give 12, 24 and 12 as the chromosome numbers in stages **A**, **B** and **D**. Candidates appeared to forget that in the mitotic cell cycle the number of chromosomes *inside nuclei* remains constant.

(b) There were many well written and detailed accounts of the role of stem cells. Some candidates demonstrated background knowledge and even wrote about the importance of totipotent, pluripotent and multipotent stem cells, although there was no information about these in **Fig. 3.3**. Candidates often stated that stem cells can divide by mitosis, but did not qualify this by making it clear that they divide continually. Roles in growth, repair of tissues and replacement of cells were given on many scripts, often with relevant mammalian examples. Although many candidates wrote about the differentiation of stem cells, they did not say that during growth they form tissues and/or organs, as might have been prompted by careful reading of the introduction to **Fig. 3.3**. Many

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candidates focused on the role of stem cells in the immune system, which was not relevant to the question.

Question 4

(a) (i) Almost all candidates identified **R** and **P** as the most effective antibiotics for treating infections of bacterium **X** and **Y** respectively.

(ii) There was much confusion between antibiotics and antibodies in the answers to this question. Many candidates read the question as asking about the use of antibodies in treating the two bacteria and wrote about interactions between the antigens on the bacteria and the three antibiotics or, often, the three antibodies. These answers rarely gained any credit. Better answers referred to the resistance of the bacteria to some of the antibiotics, e.g. bacterium **Y** being resistant to antibiotic **Q**. Many then explained that this is because they have a gene to confer resistance. Some answers explained that antibiotics have different cellular targets, and cell wall synthesis and protein synthesis were often used to exemplify this.

(b) Many candidates needed to improve their responses by contrasting the use of vaccines in prevention of disease with the use of antibiotics in the treatment of bacterial diseases. Candidates often wrote good descriptions of the use of vaccines in the control of infectious diseases, but rarely compared these uses with those of antibiotics. A very common error was to state that while vaccines provide artificial active immunity, antibiotics provide artificial passive immunity. Some of these answers continued to write about antibiotics as if they were antibodies. A few did explain that there are vaccines for both viral diseases and bacterial diseases and that antibiotics are not used to treat viral diseases. The specificity of vaccines was noted by some candidates, but only a few contrasted this with the idea of broad-spectrum antibiotics.

Question 5

(a) (i) Most candidates completed **Fig. 5.1** to show how glycine is added to an elongating polypeptide by showing the peptide bond and the glycine residue. Many also showed that water would be formed, although there was no mark for this. A common error was to join glycine to the C terminal of the polypeptide through an oxygen atom.

(ii) Most stated that the reaction shown in **Fig. 5.1** is a condensation reaction. Some gave dehydration, which was also accepted, and others gave hydrolysis, which was not.

(iii) Candidates often did not make it clear that each collagen molecule is composed of three polypeptides that are closely packed together in a triple helix. Many explained that the polypeptides are found in a 'tight coil' which does not convey the right idea. Many knew that glycine is the smallest amino acid but did not always relate this to the close packing of the three polypeptides. Many also stated that glycine formed a third of the amino acids in each polypeptide without making it clear that it is every third amino acid in the primary structure of each polypeptide. Large numbers of candidates referred to the high tensile strength of collagen, which was not credited here.

(b) This question asked candidates to explain how the structure of collagen is related to its functions. Many candidates stated that collagen has high tensile strength but were often too imprecise in their descriptions of the structure to gain much credit. For example, it was not clear where hydrogen bonding and covalent bonding occurs in collagen. Few candidates stated clearly that there are many hydrogen bonds between the polypeptides in each collagen molecule and covalent bonds between collagen molecules. Many described the arrangement of molecules into fibrils and fibrils into fibres. Many also gained a mark for stating one place in the mammalian body where collagen is found. There were good accounts of the role of collagen in the trachea, in tendons and in arteries, but these tended to be few and far between. Some candidates referred to glycosidic bonds and the structure of cellulose rather than collagen. Some candidates thought individual hydrogen bonds were strong, rather than stating that it is the presence of many bonds that provides strength. Some candidates confused collagen and elastin. Those who made reference to the elasticity of collagen did not gain credit for naming a part of the body where collagen is found.

(c) Candidates tended to know what happens to an enzyme that uses an induced fit mechanism. They tended to begin by stating that collagen is not complementary to the active site of collagenase and then stated that the active site 'moulds itself' around the collagen so it does fit. To gain credit for these answers the candidates had to include the term *complementary*. It was also important to

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make clear that it is the shape of the active site that is relevant as opposed to the shape of the enzyme molecule. Some candidates stated that it is the substrate collagen that changes shape in the induced fit mechanism. Further points that were often given included the formation of an enzyme-substrate complex and the lowering of the activation energy. Very few stated that in the reaction, peptide bonds are broken and that after the reaction the active site returns to its original shape and can accept another substrate molecule.

(d) There were many answers that simply described the effect of pH on the activity of collagenase. Many of these were illustrated by data taken from the graph – more than was really necessary. Candidates who wrote these answers then often gave a very brief explanation, or no explanation at all. A common error was to state that at extremes of the pH range investigated, the enzyme is denatured. If this was the case, the activity would be zero. Candidates who said that the enzyme was partially denatured or 'was beginning to denature' gained credit. However, very few stated that the partial denaturation occurs both in acid and alkaline conditions. Many stated that the effect of changes in pH is to break hydrogen and/or ionic bonds, but few explained in sufficient detail that this leads to a change in the tertiary structure and/or shape of the active site so that collagen no longer fits (as effectively) into the active site.

Question 6

(a) Candidates were confident about answering this question on magnification. Most gave the correct formula in the box and showed all their working to give the correct answer (×200).

(b) (i) Most candidates identified the process occurring in *Vorticella* as endocytosis or phagocytosis. References to pinocytosis, pseudopodia and bulk transport were not credited. In a number of responses, descriptions of the process could have been clearer and many wrote about phagocytosis occurring in a *phagocyte* rather than in a single-celled organism. Membrane fusion to form a food vacuole was seen quite rarely. Often candidates did not describe the final stage in the process where the vesicle pinches off from the membrane. There were many references to 'infolding' of the membrane, but as that term was given in the stem of the question it was not given credit.

(ii) Candidates often stated that lysosomes contain hydrolytic enzymes and that they fuse with phagosomes. Candidates rarely gave examples of these enzymes or described their mode of action. Some mentioned lysozyme as an enzyme, but few knew what it did. Some confused lysosomes and lysozyme and some referred to all the enzymes in the lysosome as lysozymes.

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Paper 9700/31
Advanced Practical Skills 1

Key messages

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

Candidates should be able to identify the significant sources of error in an investigation as any variable that may change during the recording of results, so making the results less accurate. Contamination is not considered a significant source of error since washing correctly should remove contamination.

Candidates should also be able to identify systematic or random errors from using apparatus in an investigation and understand that systematic errors do not affect the trend in results whereas a random error, for example, due to variability of biological material, may affect the trend and accuracy.

General comments

The majority of centres returned the Supervisor's report and the seating plan with the candidate papers. The information included in the Supervisor's report is essential, as any problems encountered by the candidates, or factors such as the temperature in the laboratory, can be taken into account when marking the candidates' scripts.

Candidates who have used materials and apparatus during practical work as part of the course are likely to perform better in the examination. Whilst the activities in the examination may not be familiar, candidates who have had the opportunity to follow instructions carefully, in a variety of practical work, are likely to find it easier to organise and complete unfamiliar activities.

The majority of centres provided all the materials required and the majority of the candidates experienced no problems with materials or apparatus when completing the question paper.

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

Candidates and Supervisors should not be concerned if the results obtained are very variable, as consistency of results within a centre is not being assessed.

Comments on specific questions

Question 1

(a) (i) Many candidates gained credit for showing the correct volumes of **M** and **W** required to make at least three additional concentrations of milk. The most common error was preparing different concentrations of milk that did not make up total volumes of 10 cm^3.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. Many candidates included a detailed heading for the independent variable (percentage concentration of milk) and the dependent variable (time / s). Common errors were to omit the heading for the independent variable, or to include 'seconds' in the body of the table. The majority of candidates gained credit for recording more than one trial, showing mean results and recording the times as whole numbers.

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(iii) Most candidates correctly described the trend shown in the results.

(iv) The majority of candidates correctly recorded the time taken for the drop of **U** to reach the bottom of the test-tube and included the appropriate units.

(v) Most candidates correctly estimated the concentration of milk in **U** according to their results.

(vi) Some candidates correctly described an improvement to the procedure by stating that changing the copper sulfate solution for each trial would reduce the effect of milk sometimes staying at the top of copper sulfate solution.

Some candidates correctly described an improvement to the procedure by stating that using a test-tube with a wider diameter, or using a beaker, would reduce the effect of the drop sticking to the side of the test-tube.

Some candidates suggested that the drop did not always reach the very bottom of the test-tube and that an improvement was to draw a line 2–3 cm from the bottom of the test-tube and stop timing when the drop reached that line.

(vii) Some candidates correctly stated that error 2 was a random error and gave the reason that the drop did not stick to the side or the test-tube every time during the procedure.

(b) (i) Most candidates correctly used the headings given in the table to label the *x*-axis (type of mammal) and the *y*-axis (mean fat globule diameter / μm). 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 2 to 2 cm for the *y*-axis and plotted each bar accurately. Stronger candidates drew ruled lines for the bars so that the vertical lines precisely joined with the horizontal lines. The most common error was drawing lines which were not ruled.

(ii) Some candidates correctly suggested that buffalo milk contained fat that took the longest time to be broken down by enzymes. They then explained that buffalo milk had the highest mean fat globule diameter and the smallest surface area to volume ratio, so less area for the attachment of enzymes compared to the volume of the fat globule.

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 top half of the root. Many candidates gained credit for drawing at least two layers of tissue and the correct proportion of the stele in relation to the diameter of the root. Stronger candidates showed detail of the tissues making up the stele. Some candidates used a label line to correctly identify the endodermis.

(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 xylem vessel element, three adjacent cells with each cell touching at least one other cell, and 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 to show the lumen of one cell.

(b) Most candidates identified at least one observable similarity and one observable difference between the root section in **Fig. 2.1** and the root section on **J1**. Many candidates stated that both roots had central vascular tissue or that they were both circular in shape. Some candidates stated that the root in **Fig. 2.1** had hairs while the root on **J1** did not and that the outer layer of the root in **Fig. 2.2** was smooth and continuous while the outer layer of **J1** was not continuous.

(c) Some candidates accurately measured the diameter of the whole root section and the diameter of the vascular tissue and showed the appropriate units. Stronger candidates showed the measurement of the diameter of the vascular tissue divided by the measurement of the diameter of the whole root section, multiplied by 100, with the answer given to the appropriate degree of accuracy.

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Paper 9700/33
Advanced Practical Skills 1

Key messages

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

Candidates should be aware that the command word indicates how the candidate should respond. The command word 'explain' implies that reasoning or reference to theory is required. It is another way of asking candidates to 'give reasons for'. If a question states, 'explain the shape of the graph between 10°C and 40.0°C and between 40°C and 55°C' the candidate needs to refer to increased kinetic energy and the formation of more enzyme-substrate complexes between 10°C and 40.0°C and the shape of the active site changing between 40°C and 55°C leading to the substrate being unable to bind and fewer enzyme-substrate complexes being formed.

General comments

The majority of centres returned the Supervisor's report and the seating plan with the candidate papers. The information included in the Supervisor's report is essential, as any problems encountered by the candidates, or factors such as the temperature in the laboratory, can be taken into account when marking the candidates' scripts.

Candidates who have used materials and apparatus during practical work as part of the course are likely to perform better in the examination. Whilst the activities in the examination may not be familiar, candidates who have had the opportunity to follow instructions carefully, in a variety of practical work, are likely to find it easier to organise and complete unfamiliar activities.

The majority of centres provided all the materials required and the majority of the candidates experienced no problems with materials or apparatus when completing the question paper.

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

Candidates and Supervisors should not be concerned if the results obtained are very variable, as consistency of results within a centre is not being assessed.

Comments on specific questions

Question 1

(a) (i) The majority of candidates gained credit for assessing the risk of the procedure as low or medium and giving a reason for their answer, such as there were no hazards listed in **Table 1.1**.

(ii) Many candidates gained credit for showing the correct volumes of **Y** and **W** required to make at least four additional concentrations of yeast suspension.

(iii) Most candidates organised their results clearly by presenting a ruled table. Stronger candidates included the heading for the independent variable (percentage concentration of yeast suspension) and the dependent variable (time / s). The majority of candidates gained credit for recording the times for all the concentrations of yeast suspension. Many candidates recorded results which

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showed that the time for the highest concentration of yeast was shorter than the time for the lowest concentration of yeast. Stronger candidates recorded times as whole seconds.

(iv) Many candidates correctly stated that one significant source of error in the investigation was the difficulty of judging when the indicator changed to yellow. Some candidates correctly stated that a source of error was not being able to maintain the water-bath between 35°C and 40°C. Some candidates also correctly stated that there was a delay putting the bung into the large test-tube which allowed some carbon dioxide to be lost.

(v) Many candidates gained full credit for describing appropriate apparatus and a suitable method. Some correctly described the use of an inverted measuring cylinder filled with water, or the use of a gas syringe. A common error was to describe a method involving counting bubbles, which was not credited as it is does not measure the volume of carbon dioxide given off.

(b) (i) Many candidates correctly identified the temperature at which the beads rose the fastest as 40°C. Fewer candidates were able to calculate the rate at which the beads rose to the surface. A common error was to omit the units, cm s^{-1} or cm per second.

(ii) The majority of candidates drew the graph, using the headings temperature / °C on the *x*-axis and mean time to rise / s on the *y*-axis. Stronger candidates used scales of 10 to 2 cm for the *x*-axis and 20 to 2 cm for the *y*-axis, plotted the points exactly with a small cross or dot in a circle and drew a 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.

(iii) Many candidates correctly described the trend shown by the graph and stated that as the temperature increased the time taken for the beads to rise decreased, and after 40°C, as the temperature increased, the time taken for the beads to rise increased. A common error was to describe the trend without reference to 40°C.

(iv) Some candidates correctly explained that between 10°C and 40°C the increase in temperature increased the kinetic energy of enzyme and substrate, leading to more successful collisions, and between 40°C and 55°C the shape of the active site changes, preventing the substrate from binding to the active site.

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 sector of the stem. Many candidates gained credit for drawing at least two layers of tissue and the correct shape and proportion of the vascular tissue in relation to the depth of the stem. Stronger candidates showed subdivision of the vascular bundle. Most candidates used a label line 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 four adjacent cells from the central region, with each cell touching at least two of the other cells, and 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 to show the cell wall of one cell.

(b) (i) Many candidates correctly measured the width of the stem and the width of the central air space and stated the appropriate units. Many candidates then showed the correct ratio of the total width of the stem to the width of the central air space. A common error was to include units with the ratio.

(ii) Some candidates correctly described how to take multiple measurements of the total width and the width of the central air space, and then calculate the mean widths.

(iii) Many candidates listed at least three observable differences between **K1** and **Fig. 2.2**. For instance, there were more vascular bundles in **K1** and fewer in **Fig. 2.2**, the vascular bundles in **K1** were close to the epidermis and the vascular bundles in **Fig. 2.2** were located towards the centre of the stem and the central region in **K1** was filled with cells while there were no cells in the central region in **Fig. 2.2**.

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Paper 9700/34
Advanced Practical Skills 2

Key messages

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

Candidates should be aware that the command word indicates how the candidate should respond. The command word 'explain' implies that reasoning or reference to theory is required. It is another way of asking candidates to 'give reasons for'. If a question states 'explain the change in rate of reaction between 0.00 mol dm^{-3} of maltose and 3.95 mol dm^{-3} of maltose' the candidate needs to refer to the increase in substrate concentration leading to an increased formation of enzyme-substrate complexes between 0.00 mol dm^{-3} and 2.45 mol dm^{-3} and the rate of reaction remaining constant between 2.45 mol dm^{-3} and 3.95 mol dm^{-3} due to all the active sites being occupied.

General comments

The majority of centres returned the Supervisor's report and the seating plan with the candidate papers. The information included in the Supervisor's report is essential, as any problems encountered by the candidates, or factors such as the temperature in the laboratory, can be taken into account when marking the candidates' scripts.

Candidates who have used materials and apparatus during practical work as part of the course are likely to perform better in the examination. Whilst the activities in the examination may not be familiar, candidates who have had the opportunity to follow instructions carefully, in a variety of practical work, are likely to find it easier to organise and complete unfamiliar activities.

The majority of centres provided all the materials required and the majority of the candidates experienced no problems with materials or apparatus when completing the question paper.

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

Candidates and Supervisors should not be concerned if the results obtained are very variable, as consistency of results within a centre is not being assessed.

Comments on specific questions

Question 1

(a) (i) Many candidates correctly drew a serial dilution of 1.0% starch solution, showing the correct concentration below each beaker, the transfer of 1 cm^3 of the previous concentration to the next beaker and adding 9 cm^3 of distilled water to each beaker. The most common error was recording a volume of 1.0% starch solution and a volume of distilled water added to each beaker to make a total of 10 cm^3.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. Stronger candidates included the heading for the independent variable (percentage concentration of starch solution) and the heading for the dependent variable (symbols). The most common error was not including the correct heading for the dependent variable.

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The majority of candidates gained credit for recording the results as symbols for at least four concentrations of starch and correctly recording results which showed that the highest percentage concentration of starch was blue/black and the lowest percentage concentration of starch was brown or yellow/orange.

(iii) The majority of candidates correctly recorded the result for **X** and **Y** using the symbols shown in the key.

(iv) Many candidates correctly estimated the correct concentrations of starch in **X** and **Y**.

(v) The majority of candidates correctly stated the use of Benedict's solution for measuring the concentration of reducing sugar in a semi-quantitative test. Some candidates described the use of different concentrations of reducing sugar to make colour standards. Few candidates measured the time to first colour change using known concentrations. Some candidates correctly suggested comparing the colour of the reducing sugar sample with colour standards of known concentrations. Few candidates compared the time to first colour change of the reducing sugar sample with time to first colour change of known concentrations. A common error was to just describe the method for the Benedict's test and the colours produced, without the link to colour standards.

(b) (i) The majority of candidates drew the graph correctly, using appropriate headings for the axes. Stronger candidates used scales of 1.00 to 2 cm for the *x*-axis and 50 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 that accurately connected the points. The most common errors were not including a plot at 0.00 mol dm^{-3} and incorrect plotting of some of the points.

(ii) Most candidates correctly determined $½V_{max}$ from the graph and some candidates used this value to read off the correct value for K_m.

(iii) Many candidates correctly identified the enzyme with the lower affinity and some were able to state that it had a higher value of K_m.

(iv) Some candidates correctly explained that at low concentrations of maltose, maltose was the limiting factor. Other candidates explained that as the concentration of maltose increased there was an increase in concentration of substrate molecules, resulting in more successful collisions between substrate and enzyme molecules and therefore more enzyme-substrate complexes being formed. Some candidates correctly explained that above 2.45 mol dm^{-3} the active sites of the enzymes were saturated with substrate molecules. A common error was to describe what the graph was showing rather than to explain why there was a change in rate.

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 correct sector of the stem. Stronger candidates gained credit for drawing at least two layers of tissue and the correct shape and proportion of the vascular bundle in relation to the corner extension of the stem. Some candidates showed subdivision of the vascular bundle. Many candidates used a label line to correctly identify the xylem.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin continuous lines which joined up precisely and used most of the space provided. Many candidates were able to draw four adjacent cells from the central region, with each cell touching at least two of the other cells and with double lines representing the cell walls. Stronger candidates showed the correct shape of the cells. The most common error was to draw lines that did not meet up precisely. Most candidates used a label line to show the cell wall of one cell.

(b) (i) Most candidates correctly measured the diameter of the stem and the diameter of the inner layer using the lines **A**, **B** and **C** and included the appropriate units. Many candidates then showed the calculation of the mean for the diameter of the stem and the diameter of the inner layer. Many also showed the division of both means by the magnification. Stronger candidates showed the answer to the appropriate degree of accuracy. Common errors were to measure the whole of each line

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instead of the diameter of the stem and not measuring the correct length of each line representing the inner layer.

(ii) Many candidates showed the correct ratio of the mean actual diameter of the whole stem to the mean actual diameter of the inner layer. A common error was to not use whole numbers in the ratio.

(iii) Many candidates listed at least three observable differences between the stem section in **Fig. 2.3** and the stem section on **L1**. For instance, the stem in **Fig. 2.3** was a square shape whereas **L1** was a circle shape, the vascular tissue was in a continuous ring in **Fig. 2.3** and in separate vascular bundles on **L1** and the central region of **Fig. 2.3** was filled with cells while there were no cells in the central region of **L1**.

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Paper 9700/35
Advanced Practical Skills 1

Key messages

Candidates should be given the opportunity to experience a variety of practical work throughout the course in order to develop the necessary skills to engage with this examination.

Candidates should be aware of the difference between 'accurate', 'valid' and 'reliable' when planning and evaluating an experiment. To improve the accuracy of an experiment, a candidate might consider the suitability of the apparatus used, or the chosen range of the independent variable.

Candidate should ensure that the only variable which changes, in a valid experiment, is the independent variable, whilst all other variables should stay the same. To ensure an experiment is reliable, the candidate should consider the sample size or the number of repeats.

General comment

The majority of centres returned the Supervisor's report and the seating plan with the candidate papers. The information included in the Supervisor's report is essential, as any problems encountered by the candidates, or factors such as the temperature in the laboratory, can be taken into account when marking the candidates' scripts.

Candidates who have used materials and apparatus during practical work as part of the course are likely to perform better in the examination. Whilst the activities in the examination may not be familiar, candidates who have had the opportunity to follow instructions carefully, in a variety of practical work, are likely to find it easier to organise and complete unfamiliar activities.

The majority of centres provided all the materials required and the majority of the candidates experienced no problems with materials or apparatus when completing the question paper.

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

Candidates and Supervisors should not be concerned if the results obtained are very variable, as consistency of results within a centre is not being assessed.

Comments on specific questions

Question 1

(a) (i) Most candidates gained marks by correctly showing how to make a serial dilution to produce at least four additional percentage concentrations, and by giving the correct volume of both the reducing sugar and the water needed to make these concentrations. Only a few candidates made less than four final solutions and so were unable to gain full marks.

(ii) The majority of the candidates presented their data in a clear, ruled table, for which credit was given. Most provided appropriate headings for the independent variable (percentage concentration of sugar) and the dependent variable (time / s). Candidates should be reminded that units should be in the headings, not in the body of the table.

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Credit was given for recording the time taken to the first colour change in the Benedict's test for each of their prepared solutions and for correctly performing the test, such that their results showed a higher concentration of reducing sugar would take less time to the first colour change. Most candidates recorded their times in seconds and followed the instruction on how to record results which showed no colour change.

(iii) Most candidates correctly recorded the result for **U**.

(iv) Many candidates were able to use the result for solution **U** to estimate the concentration of the unknown solution, **U**.

(v) Those candidates who understood how to plan an experiment were able to suggest suitable improvements to this experiment, in order to gain a more accurate estimate of the unknown concentration of reducing sugar in solution **U**. Credit was given for suggesting more concentrations with smaller differences in concentration, and that plotting a graph of the results and then reading off the time for the unknown would give a more accurate estimate. Some candidates correctly suggested that proportional dilution would be a more suitable way of preparing the solutions, rather than by serial dilution.

(b) (i) Many candidates correctly determined $\frac{1}{2}V_{max}$ from the graph and some candidates used this value to read off the correct value for K_m.

(ii) Many candidates correctly identified the enzyme with the lower affinity and some were able to state that it had a higher value of K_m.

(iii) Many candidates were able to explain that the rate of reaction was at a maximum between 30 mmol dm^{-3} and 40 mmol dm^{-3} because the active sites of the enzymes were fully occupied, or saturated, with substrate molecules. Common errors were to state that the reaction had stopped, rather than being at maximum rate, or to state that the substrate concentration was limiting the rate of reaction.

(c) There were many well-presented graphs which had bars of equal width drawn using a ruler and a sharp pencil. Most candidates correctly labelled the *x*-axis and *y*-axis with 'type of fruit juice' and 'concentration of sugar / arbitrary units' respectively, and used an appropriate scale, 5 units to 2 cm, starting at zero on the *y*-axis. Some candidates did not draw the bars accurately enough to clearly show the value of the plot and some did not label the *x*-axis fully, identifying which bar represented which fruit juice, but then forgetting to also include the 'type of fruit juice' label.

Question 2

(a) (i) Most candidates gained credit by drawing the correct section and by carefully showing the layout and proportions of the leaf tissues. Most credit was gained by those who observed and drew the thickened tissue as a distinct layer at the leaf tip, and by drawing the epidermis in proportion to the depth of the leaf. Most candidates correctly identified and labelled the epidermis. Some candidates did not make their drawings large enough to utilise the available space.

(ii) Many candidates gained credit for producing large, carefully observed and carefully drawn cells. Most candidates followed the instructions to draw a line of four epidermal cells, with each cell touching the cell next to it. Careful observation of the shape of the cells or cell contents also gained credit. Some candidates made their drawing too small and did not take enough care when drawing the cell outlines or cell walls. Gaps in the lines and overlapping cell wall lines were not clear enough to gain credit. Similarly, a label line which did not finish in, or on, the cell wall could not gain credit.

(iii) Candidates that could correctly align the plastic ruler under the ×10 objective lens were able to measure the diameter of the field of view within an acceptable range. These candidates were also able to use slide **M1** to estimate the number of epidermal cells across the field of view with few problems. Most of the candidates were then able to calculate the mean width of an epidermal cell by dividing the diameter of the field of view by the number of cells counted, and then give their answer in micrometres. Some candidates used the wrong equation or did not show their working.

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(iv) Many candidates were able to identify the stage micrometer and eyepiece graticule as being the apparatus needed to gain a more accurate estimate of the width of an epidermal cell.

(b) (i) Most candidates were able to select one observable feature that would enable the plant to live in a dry habitat. Several identified the cuticle or trichomes whilst others noticed the shape of the leaf or the sunken stomata. The majority of these candidates also gained credit for explaining how these features would reduce water loss, and many described how evaporation or transpiration would be affected. Some candidates could not be awarded credit because they gave an incomplete reason for their stated feature. For example, explaining that the curled leaf would create an environment under the leaf which would be moist and free from air currents, without then going on to explain that this would reduce water loss.

(ii) Many candidates were able to tabulate several similarities and differences between the leaf section on **M1** and the leaf in **Fig. 2.2**. For similarities, many described features shown by all leaves, such as the presence of vascular bundles, epidermis and mesophyll. For differences, many described the shape of the leaf. Candidates should be reminded to describe the shape of both leaves instead of simply stating the opposite, for example, **Fig. 2.2** has a 'curled' leaf whereas the leaf in **M1** is 'flat', as opposed to saying that **M1** is 'not curled'. The abundance of vascular bundles, the presence or absence of trichomes, and sunken stomata were also noted by the more able candidates. A common error was to refer to the section as a cell.

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Paper 9700/36
Advanced Practical Skills 2

Key messages

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

Candidates should be aware that the command word indicates how the candidate should respond. The command word 'explain' implies that reasoning or reference to theory is required. It is another way of asking candidates to 'give reasons for'. If a question states, 'explain the effect of soil temperature on urease activity' the candidate needs to refer to increased kinetic energy and the formation of more enzyme-substrate complexes between 5°C and 45°C and the shape of the active site changing between 45°C and 55°C leading to the substrate being unable to bind and fewer enzyme-substrate complexes being formed.

General comments

The majority of centres returned the Supervisor's report and the seating plan with the candidate papers. The information included in the Supervisor's report is essential, as any problems encountered by the candidates, or factors such as the temperature in the laboratory, can be taken into account when marking the candidates' scripts.

Candidates who have used materials and apparatus during practical work as part of the course are likely to perform better in the examination. Whilst the activities in the examination may not be familiar, candidates who have had the opportunity to follow instructions carefully, in a variety of practical work, are likely to find it easier to organise and complete unfamiliar activities.

The majority of centres provided all the materials required and the majority of the candidates experienced no problems with materials or apparatus when completing the question paper.

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

Candidates and Supervisors should not be concerned if the results obtained are very variable, as consistency of results within a centre is not being assessed.

Comments on specific questions

Question 1

(a) (i) Many candidates correctly drew a serial dilution of 10% urease, showing the correct concentration below each beaker and the transfer of 5 cm^3 of the previous concentration to the next beaker and adding 5 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 (percentage concentration of urease) and the heading for the dependent variable (symbols). The majority of candidates gained credit for recording the results as symbols, for at least four concentrations of urease, and included the result for water. Many candidates also correctly recorded results which showed that the higher the percentage concentration of urease, the more distinct the blue colour.

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(iii) The majority of candidates correctly described the trend by stating that the higher the concentration of urease the more alkaline the solution.

(iv) The majority of candidates correctly recorded the result for **B** using the symbols shown in the key.

(v) The majority of candidates correctly estimated the correct concentration of urease in the bean extract, **B**.

(vi) Many candidates correctly described how to modify the procedure to produce a more accurate estimate of the concentration of urease in **B**. Some candidates correctly suggested using more concentrations of urease close to the estimated concentration of urease in **B**. Some candidates correctly suggested timing how long the red litmus took to turn blue rather than leaving each piece for 2 minutes.

(vii) Many candidates correctly stated that one source of error was the varying drop size when adding urea, urease or water and the improvement was to use a set volume using a syringe. Some candidates stated that an error was the varying times that litmus paper was in the urea and urease solutions and the improvement was to carry out an individual test for each concentration of urease. Some candidates correctly stated that another source of error was the varying size of litmus paper and that an improvement was to cut each piece exactly to size by measuring the width and length accurately.

(b) (i) The majority of candidates correctly drew the graph, using appropriate headings for the axes. Stronger candidates used scales of 10.00 to 2 cm for the *x*-axis and 10 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) Most candidates showed on the graph the point at 21°C, read off the correct value for urease activity from the graph and included the appropriate units (arbitrary units).

(iii) Some candidates correctly explained that as the temperature increased, the enzyme and substrate had more kinetic energy, resulting in more collisions between substrate and enzyme molecules, thereby forming more enzyme-substrate complexes. Some candidates correctly explained that above 45°C the shape of the active site changed and fewer enzyme-substrate complexes formed. A common error was to describe what the graph was showing, rather than to explain the effect of soil temperature on urease activity.

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 whole leaf. Many candidates gained credit for drawing at least three layers of tissue and the correct shape and proportion of the vascular bundle in relation to the depth of the leaf. Stronger candidates showed subdivision of the vascular bundle. Most candidates used a label line to correctly identify the palisade mesophyll.

(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 four adjacent epidermal cells with each cell touching one of the other cells and with double lines representing the cell walls. Stronger candidates showed the correct shape of the epidermal cells. The most common error was to draw lines that did not meet up precisely. Most candidates used a label line to show the cell wall of one cell.

(iii) Most candidates organised the table into three columns, with one column headed features, one headed upper epidermis and one headed lower epidermis. Many candidates listed at least two observable differences between the upper epidermis and the lower epidermis. For instance, there were no trichomes in the upper epidermis whereas trichomes were present in the lower epidermis, there were no stomata in the upper epidermis whereas stomata were present in the lower epidermis and the upper epidermis had larger cells than the lower epidermis.

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(b) Many candidates accurately measured the depth of the leaf shown by the line **X**–**Y** and the length of the scale bar with the appropriate units. Many candidates then showed the length of the scale bar (mm) divided by 2.5 to obtain a figure for the magnification. Stronger candidates then showed the division of the measurement for the depth of the leaf by the figure for magnification. Stronger candidates showed the answer to the appropriate degree of accuracy. The most common error was the omission of units when showing the depth of the leaf and the length of the scale bar.

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Paper 9700/41
A Level Structured Questions

Key messages

Candidates should be reminded of the differences between command words, particularly 'describe' and 'explain'. Often candidates wrote descriptions when explanations were required.

Candidates should consider the number of marks available when answering each question. This indicates the number of separate points that a candidate will need to make in order to receive full credit.

Where candidates are asked to use data provided in tables, graphs or diagrams, it is important that responses refer to the data. The data should not simply be quoted, but used to support statements, identify patterns and trends or provide evidence for conclusions, as applicable.

Successful candidates pay close attention to the wording of each question and make use of the information provided in the question contexts, integrating this with their own understanding.

General comments

Most candidates were able to demonstrate sound knowledge and understanding of the syllabus when presented with familiar contexts. Many were also able to develop effective responses in novel contexts by making links with the underlying biological principles that are embedded in the syllabus. Candidates lacking confidence when presented with unfamiliar contexts were sometimes unable to apply the relevant knowledge and understanding to engage with the assessment.

Most candidates were confident with the mathematical questions and the genetic cross. In general, **Question 1(c)(i)**, **2(c)**, **4(a)** and **5(b)(ii)** were found to be the most demanding.

Comments on specific questions

Section A

Question 1

(a) Most candidates could label an epidermal cell but parenchyma, bundle sheath and xylem cells were all mistakenly labelled as cells that contained PEP carboxylase.

(b) (i) The correct answer of bundle sheath was occasionally given but many stated mesophyll and some stated phloem or vascular bundle.

(ii) The question required a focus on anatomy, not biochemistry. Good answers showed a clear understanding of the mesophyll forming a ring around the bundle sheath cells in order to stop oxygen entering the bundle sheath cells and reacting with RuBP, so as to prevent photorespiration.

(c) (i) Candidates who read the question carefully realised that they needed only to make comparisons between two of the four lines on the graph. Candidates who gained full marks quoted figures accurately and focused on comparisons, such as the optimum temperature, the maximum rate and the change in relative uptake of C3 and C4 plants that occurred at 22 °C.

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Some candidates simply described the features of one curve and then the other. Giving the value of the maximum rate of photosynthesis in C4 plants, followed by the value for C3 plants, is not a comparison. Comparative statements include terms such as 'higher than' and 'lower than'.

Many candidates made the general statement that C4 plants had a higher rate of photosynthesis than C3 plants, even though C3 plants had a higher rate of photosynthesis than C4 plants at lower temperatures (below 22 °C). Most were able to quote data to support the difference they mentioned, and the majority quoted the full coordinates – that is, the values from both axes, with units.

(ii) Most candidates identified high CO_2 conditions as giving the higher rate. Explanations based on the idea of limiting factors sometimes omitted to state that CO_2 was limiting in low CO_2 conditions (but not in high). A few candidates compared C3 and C4 plants rather than C4 plants in the two conditions at the stated temperature range.

Question 2

(a) (i) Since all the genotypes showed a marked increase in milk yield at the second lactation, the cause was environmental, with age/maturity being the environmental variable. Many candidates did grasp this idea but few pointed out that as the change is seen in each goat in its lifetime it cannot be genetic (since each goat's genes remain the same). A few mentioned that hormones would be involved in the change.

(ii) Candidates readily described that the substitution increased milk yield, but few described the importance of that in terms of benefits to people (more food) or farmers.

(b) (i) The Hardy-Weinberg calculation was done well by many. The values of *p* and *q* had been provided so a candidate who understood the principles had fewer steps of calculation to perform. Some rounded the total down instead of up and could not be credited. Common errors were to forget to multiply by the population size (268) or to omit the 2*pq*. Some candidates mis-quoted the total number of goats as 267, with consequent effects on their final numbers of **CC** and **CG** goats.

(ii) The correct answer of chi-squared test was the commonest answer. Incorrect answers included *t*-test and Simpson's index.

(iii) Most candidates described the difference in predicted and actual numbers but fewer gave good reasons for the departure from Hardy-Weinberg equilibrium that they described. General points that could be made included migration, genetic drift and non-random mating. In view of the information provided in the question, candidates who suggested selection needed to use that information to argue that selection was acting against the heterozygotes (whose numbers were smaller than predicted) or in favour of the high-yielding **CC** goats. Mutation was not credited as the question made it clear that the mutation was a new one.

(c) Some candidates did not understand that a therapeutic recombinant protein produced in milk would be purified and given as a drug to people who lacked that specific protein. Weaker responses made reference to people drinking the milk to remedy a general protein deficiency, while stronger responses talked about treating a genetic disease. The ethical problems covered human side effects and animal welfare concerns as well as well-argued answers about vegetarian and vegan people objecting to consuming an animal product. Unspecific references to religious beliefs could not be credited.

Question 3

(a) Many candidates wrote excellent answers based on their understanding of allopatric speciation, but in the question context of subspecies (rather than species) evolving. Misspellings of geographical (e.g. geometric, geomatic) could not be credited. Those who described isolation needed to reference separation of populations (not sub-species or species) since at the initial isolation stage the birds would be fragments of one original population.

(b) Good answers to this used the information provided in the question and talked about comparison of the mitochondrial gene sequence, not alternative techniques such as genetic fingerprinting or whole genome sequencing.

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(c) The strongest answers argued that the use of a DNA barcoding device would help to catch or stop the activities of illegal traders and poachers and would prevent entry into a country of alien species that posed a threat to native endangered species.

Question 4

(a) Many answers didn't trace the essential changes from the altered amino acid to the formation of different bonds that caused adjacent haemoglobin molecules to stick together. A common error was to equate haemoglobin molecules with red blood cells and to discuss these sticking together.

(b) (i) Many candidates expressed a vague idea of more oxygen being present, preventing symptoms. A more rigorous analysis specifies that the partial pressure of oxygen in capillaries is higher, reducing HbS fibre formation and so reducing the blockage of capillaries (and associated pain) by sickled red blood cells.

(ii) The correct answer of transcription factor was commonly given. Regulatory protein was also acceptable but some candidates mistakenly described this as a regulatory gene.

(c) (i) Many candidates knew details of the process of electrophoresis but some incorrectly referred to DNA being separated, rather than the haemoglobin proteins. Strong candidates used the information given in the question to reason that HbS would travel more slowly or would move a shorter distance towards the anode.

(ii) Candidates who had followed the information given in the question were able to apply their understanding to gain two marks here.

Question 5

(a) This cross yielded full marks for many candidates. As one of the parents was homozygous recessive there was only one gamete type from that parent, simplifying the work that had to be done. Errors included not using the information in line one ('recessive phenotype for two unliked genes') to correctly work out the genotype of the cat in Fig. 5.1, not linking offspring genotypes to phenotypes and not writing out organism genotypes as diploid, with two alleles for each gene.

(b) (i) Many candidates explained that two pointed parents always give pointed offspring (i.e. the pointed characteristic breeds true), or that two full colour parents can produce a pointed offspring. Some identified that pointed individuals were always homozygous for the allele that lacked the restriction site.

(ii) Candidates struggled to express ideas about sex linkage in words and in the context of the pedigree diagram. Valid points were that the male cats on the pedigree had two copies of the DNA sequence thought to code for full colour or pointed and that sons inherited a copy from their father, or had their colour phenotype influenced by their father and not just their mother.

(iii) Some candidates correctly identified that the marker locus is inherited together with the DNA sequence that has, or does not have, the restriction site, with some identifying that in the cats on the pedigree diagram the minus (no restriction site) allele is always associated with a marker locus number of 1 – 4, while the plus (has the restriction site) allele is always associated with a marker locus number of 6 or 7. Sensible references were made to no crossing over occurring, with the strongest answers identifying that the bottom right-hand cat inherited the paternal and maternal combinations with no recombinant combinations appearing.

Question 6

(a) (i) Many candidates correctly stated the locations of the components of a cholinergic synapse. However, there was some confusion over mitochondria being in the cytoplasm of the presynaptic neurone whose membrane allowed for exocytosis of Ach when the membrane's voltage-gated channels were stimulated, and that Ach acts as the ligand that then binds to the ligand-gated channels on the postsynaptic membrane. While the swollen end of the pre-synaptic neurone allows it to be called a 'knob' this is not true of the post-synaptic neurone, though a few candidates mistakenly referred to a 'post-synaptic knob'.

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(ii) Many candidates were well-prepared and could list more than two roles of synapses in the nervous system.

(b) Good answers picked up on the question information that organophosphates inhibit an enzyme in the neuromuscular junction. They therefore followed a logical sequence of reasoning from the inhibition of acetylcholinesterase through to Ach staying bound to receptors, sodium ion channels staying open and the sarcolemma staying depolarised, giving constant muscle contraction. Weaker answers invented alternative modes of action for organophosphates that were not based on the information given in the question.

(c) Most candidates showed some knowledge of the sarcoplasmic reticulum releasing calcium ions which bind to troponin, moving tropomyosin so that actin can bind to myosin. Candidates should take care to distinguish troponin, tropomyosin and myosin by spelling these names correctly.

Question 7

(a) Most candidates gained a large proportion of the marks for matching the names of compounds and sites in cellular respiration in anaerobic conditions, with their descriptions.

(b) Candidates were generally knowledgeable about the role of oxygen breathed in to repay the oxygen debt.

Question 8

(a) Most candidates read the yields per hectare for oil palms and soya beans correctly, and divided the oil palm figure by the soya bean figure to obtain the number of hectares of soya beans that would need to be planted to give the same yield as one hectare of oil palms. Errors included calculating a percentage.

(b) Stronger candidates listed five or more reasons why it is important to maintain biodiversity.

(c) Answers that did not gain one of two marks for describing possible consumer actions often did not refer to the goal of obtaining palm oil sustainably. A suggestion that did not answer the question included consumers switching to alternative oil sources.

Section B

Question 9

(a) Candidates commonly made reference to these properties of plasmids: that they are small, circular and may contain genes for antibiotic resistance. It was rarer to see comments on their being able to replicate independently or that they consist of double-stranded DNA. Saying that they can be cut by restriction enzymes is not describing a property of a plasmid as precisely as saying that they have restriction sites. These properties were meant to be linked to the use of plasmids in gene cloning, so suggestions about their ability to travel in the body for gene therapy or their having a promoter controlling expression of an inserted gene were not relevant. Candidates did often comment on the small size being linked to ease of uptake by a host bacterium and the marker genes being useful for identifying transformed recombinant cells.

(b) The roles of the three enzymes were well-described by many candidates. The general point that restriction endonucleases cut DNA (before specifying certain sub-types of DNA like plasmids and genes of interest) was sometimes missed. Similarly, candidates sometimes made the mistake of saying that reverse transcriptase ‘converts’ mRNA into cDNA rather than saying that it uses mRNA as a template in order to construct a complementary cDNA.

Question 10

(a) The majority of candidates knew how adrenaline stimulates liver cells to convert glycogen to glucose and explained each step of the signalling cascade in relevant detail, including G protein activation, adenyl cyclase making cAMP from ATP, activation of kinase and signal amplification. A few candidates talked about glycogen or glucagon stimulating the liver cells, and some answers focused entirely on insulin and glucagon and did not answer the question with reference to adrenaline at all.

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(b) Many candidates knew the role of ABA in closing stomata in times of drought and they wrote detailed, step-by-step accounts that were logically consistent and explained the full process. Some answers made no reference to guard cells being the site of ABA binding and the subsequent changes. A common error was for candidates to call the guard cell pair the 'stoma' rather than using this name for the hole that transiently exists between them.

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Biology

Paper 9700/42
A Level Structured Questions

Key messages

Candidates should be reminded of the differences between command words, particularly 'describe' and 'explain'. Often candidates wrote descriptions when explanations were required.

Candidates should consider the number of marks available when answering each question. This indicates the number of separate points that a candidate will need to make in order to receive full credit.

Where candidates are asked to use data provided in tables, graphs or diagrams, it is important that responses refer to the data. The data should not simply be quoted, but used to support statements, identify patterns and trends or provide evidence for conclusions, as applicable.

General comments

Most candidates were able to demonstrate sound knowledge and understanding of the syllabus when presented with familiar contexts. Many were also able to develop effective responses in novel contexts by making links with the underlying biological principles that are embedded in the syllabus. Candidates lacking confidence when presented with unfamiliar contexts were sometimes unable to apply the relevant knowledge and understanding to engage with the assessment.

In general, **Question 1(c)(ii)**, **3(b)**, **4(b)(ii)**, **5(a)(ii)** and **5(a)(iv)** were found to be the most demanding.

Comments on specific questions

Section A

Question 1

(a) Most candidates correctly identified one of the starch grains as the carbohydrate storage product from the electron micrograph. Fewer candidates identified the stroma as the site of the light independent reaction. Incorrect responses included labelling a different starch grain or one of the networks of thylakoid membranes. Candidates should ensure that label lines end exactly on the structure to be labelled.

(b) (i) Whilst many candidates identified the labelled structure as a granum, less specific answers stated that this was a thylakoid (singular), not recognising the importance of the larger structure.

(ii) Nearly all candidates recognised that the grana possessed photosynthetic pigments, or photosystems, and are the site of the light dependent reaction. There were a good number of responses that missed out on the absorption of light energy mark as they did not state that it is light 'energy' or they used other descriptors such as 'trapped'. Fewer candidates described that the grana had a large surface area or that there were large numbers of enzymes/ETC/ATP synthase, despite many mentioning that these were present.

(c) (i) Many candidates correctly described photorespiration, including the use of this term, to obtain full marks. Some candidates described the denaturation of proteins or the closure of stomata and subsequent reduction in gaseous exchange without describing why this could lead to photorespiration.

(ii) This was a demanding question. The graph showed decreasing atmospheric carbon dioxide concentrations and candidates needed to link this to the evolution of C4 plants that can

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photosynthesise at lower carbon dioxide concentrations when the ratio to oxygen is relatively higher. Whilst many candidates identified this occurrence, many incorrectly linked this to the appearance of C4 plants causing this reduction in atmospheric carbon dioxide rather than evolving in response. Many only achieved one mark for stating that carbon dioxide levels were decreasing. Several responses misapplied the graph's *x*-axis and believed they had to read it in reverse thus claiming that carbon dioxide levels were increasing.

Question 2

(a) Few candidates gained both marks because they did not subtract the milk yield of a native South African goat from the milk yield of the Saanen breed. Most candidates were able to give the answer to two significant figures. A minority misunderstood the concept of 'how many times greater' and so incorrectly included kg as a unit.

(b) (i) Many candidates missed the idea that to assess if this is due to genetic causes, the different goat breeds in the same location needed to be analysed. Those who did get the right idea either gave a general explanation of different breeds having different milk yields in the same environment or listed the different breeds at particular location, adding the yields of each. A significant number of candidates either did not give the units or provided units qualifying the wrong point. Very few commented on the different goat breeds having different gene pools and none on the effect of selective breeding. Candidates sometimes missed out on a mark for reference to individual 'goats' or 'goat species' rather than the required 'goat breeds'. Candidates should take care to select and quote data, with units, which supports the trend they state.

(ii) A majority of candidates described the type of environment found in the different locations and tried to link this to higher or lower yields – some missing out on this mark for vague references to the environment 'affecting' the yield rather than saying how it affected the yield. As with **2(b)(i)**, general reference to the same breeds at different locations producing different milk yields or specific reference to one breed in different locations were commonly credited, though a significant number wrote their explanation the wrong way round. There was the similar situation as with **2(b)(i)**, where candidates did not correctly quote data.

(c) Many candidates were able to describe a programme of selective breeding and describe it as artificial selection. One of the most common errors was to talk about breeding offspring without first having commented on selecting those with the desired characteristics. Few candidates recognised this as directional selection, even fewer referred to progeny testing within the process. Some candidates didn't use the information given, and simply talked about goats with a high milk yield, rather than referring to Saanen goats. A few candidates described IVF programmes and artificial insemination, rather than selective breeding.

(d) The benefit of reducing diarrhoea was a very common response. Some answers lacked precision, such as giving vague references to reducing infections and diseases. Many candidates could give a valid disadvantage to making GM milk available. Some mistakenly stated that these goats were too expensive, rather than stating a disadvantage caused by the milk.

Question 3

(a) This question was generally well answered. The majority of candidates recognised this as allopatric speciation and explained that geographical isolation occurred leading to the separated populations having different selection pressures and different mutations. Some incorrectly referred to the two **species** being separated and not breeding, rather than two populations. Mutations were often referred to but not usually as being 'different'. It was not uncommon for candidates to incorrectly suggest that the mice developed mutations to enable then to survive in the different environments. A few candidates did recognise this as being caused by the process of natural selection as some individuals gained a selective advantage but then some incorrectly referred to alleles, not individuals, having a selective advantage.

(b) Candidates found this a very demanding question. Although some candidates obviously recognised the terms pre-zygotic and post-zygotic isolating mechanisms, they did always answer the question. Some candidates confused pre-zygotic and post-zygotic, others consistently omitted to refer to hybrids. Many candidates did not understand the comparative and evaluative elements of this question. Many listed plausible pre-zygotic mechanisms, having not picked up on the mating between the two sub-species, and thus discounting pre-zygotic isolating mechanisms being

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involved in maintaining the two species as separate species. For post-zygotic isolation mechanisms, many candidates recognised the different chromosome numbers in the subspecies but only a few candidates then went on to link this to problems completing meiosis. For those that used the term 'hybrid' in their explanation of post-zygotic factors, they often achieved marks for commenting on hybrid sterility and the likelihood of their early death.

Question 4

(a) Many candidates recognised that oxygen would not reach the tissues and organs but were unable to link this to respiration. Some neglected to refer to the consequences to cells or tissues, and instead mentioned heart attacks and strokes, whilst some talked about capillaries bursting.

(b) (i) Many candidates gained full marks here though some did not recognise that the mother was already pregnant and talked about couples making decisions about future pregnancies after their diagnosis. Some candidates described the idea of 'parents preparing' but did not qualify this; for example, mentally or financially prepared.

(ii) Although it was clear that many candidates are aware of what a primer is, many could not describe why it is used in PCR and few actually described that it binds to DNA, or that it allows DNA polymerase to bind to DNA. More able candidates did describe this, however, very few were able to go on to describe how the specific primers allowed amplification of the three separate genotypes. A few candidates did recognise that when both primers did bind to DNA it meant that the genotype was SCT.

(iii) Many candidates found it difficult to interpret these results correctly and could not give accurate genotypes. It was not uncommon for responses only to include the genotypes. The phenotype for the heterozygous genotype was often given as 'normal' or 'carrier', instead of having an SCT phenotype.

(c) (i) Most candidates were able to describe that those with SCT were able to survive, with some also recognising that having the sickle cell allele allows them to have a selective advantage. Weaker responses described 'people with sickle cell anaemia' as surviving better, not differentiating between SCT and homozygous recessive sickle cell disease. A small number of candidates to mentioned that this was stabilising selection. Many candidates correctly identified malaria and sickle cell anaemia as selection pressures.

(ii) This question was generally well answered. Candidates frequently referred to 'designer babies', discarding embryos and PGD being against religious beliefs. However, some candidates were confused and talked about abortion even though the embryo had not yet been implanted.

Question 5

(a) (i) Most candidates could identify codons 976 and 977 as having base substitutions, but a few could not be awarded the mark as they didn't explain what the specific substitution was in either case. Some candidates didn't name the amino acid that was coded for in both cases, instead stating that it was just the same one. A few incorrectly stated that the codons 'produced' the same serine amino acid. There was little use of the term 'degenerate'.

(ii) Stronger candidates recognised that a base had been deleted causing a frame shift. Some candidates wrote about the change in the amino acid sequence, rather than the DNA sequence. Candidates that identified the deletion, frequently did not specify its location so could not be awarded the mark. Many could identify the occurrence of a frame shift even if they did not go on to explain the consequences of it for the following codons.

(iii) The majority of candidates were able to recognise that no tyrosinase enzyme would be made, or if it was, it would be non-functional. Most were able to gain credit for the idea that there would be a change in tertiary structure of a protein.

(iv) Few candidates were able to explain why bioinformatics was used. In particular, candidates did not appreciate that a large amount of data can be stored. Although some realised that similarity in data meant that there was some common ancestry, very few appreciated that more similarity meant there was a more recent common ancestor.

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(b) A large number of candidates found this demanding. Some were able to deduce the albino genotype, but many could not give the genotype of a fully pigmented parent who was going to produce kittens with Siamese colouring. Some candidates gained credit for deducing the correct F1 as an error carried forward from incorrect parents.

Question 6

(a) Many candidates were able to use information given in the diagram to explain the first part of the action of opioid drugs on synapses. Those who had a good knowledge of synaptic transmission were able to gain full credit. A lack of precision prevented some candidates from being awarded marks. For example, candidates should remember that ions pass through, not into, a membrane and that membranes, not neurones, become depolarised. Many did not state that the neurotransmitter was acetylcholine.

(b) (i) Nearly all candidates described the spinal reflex as an automatic response. Many gave descriptions of the response being fast despite this being highlighted in the question.

(ii) Many descriptions of the site of the cell bodies for different types of neurone were ambiguous, particularly for the sensory neurone. Some answers stated the brain, despite the question being in the context of a spinal reflex.

(iii) There were some good responses that clearly described the role of both sensory and motor neurones in a spinal reflex. The main discriminating aspects of this question were in the source of the impulse for each neurone, particularly the sensory neurone receiving the impulse from a receptor for onward transmission. Some non-technical language such as the description of impulses as messages or signals prevented credit from being awarded. As in previous questions, some answers mentioned the brain, despite the question being in the context of a spinal reflex.

Question 7

(a) Nearly all candidates identified the insulin receptor as being a protein, although some confused this with insulin itself and described it as a hormone. The site of the insulin receptor was less well described. Many responses re-used the information in the question that told them the cell types that express this receptor, rather than the precise location as requested, where candidates needed to be explicit that this is on the cell surface membrane.

(b) (i) This percentage increase calculation proved to be demanding for some candidates. A common error was to calculate a rate of increase by incorporating the time difference into the calculation. Another common error was not dividing by the correct denominator, in this case 5, that could be identified from the value of enzyme activity at the time from which the percentage increase was being calculated from.

(ii) Nearly all candidates correctly described some aspect of the biological process in which glycogen synthase decreases the blood glucose concentration by converting the excess glucose to glycogen for storage. Only occasional answers described the breakdown of glucose, or wrote glycogen as glucagon.

Question 8

(a) Most candidates displayed some knowledge about the use of a mark-release-recapture methodology to estimate the population size of small mobile animals, even if the specific term for this methodology was not stated. Most candidates described marking the rats and the idea of catching two distinct samples. There was some imprecision in the details surrounding the counting of the populations and the requirement to allow sufficient time for mixing. Stronger responses explained the calculation used to estimate the population size from their samples. There were a small number of responses that erroneously suggested the use of quadrats or line transects for these mobile animals.

(b) (i) Although the values for inputting were provided, many candidates miscounted the *n* number from the table provided and so resulted in an incorrect value. However, there were also a good number of candidates who were able to use the value and work through the calculation correctly.

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(ii) Most candidates were credited with the mark for describing the negative correlation, as this was clearly evident from the data table. Comments on the relative strength of the correlation, being as close to –1 as it was, were rare. Credit was awarded where candidates correctly interpreted their own r_s value from the previous question if this had been incorrectly calculated.

Section B

Question 9

(a) Stronger candidates could link structural genes to coding for structural proteins and could name one, usually an enzyme. Similarly, candidates could sometimes explain that regulatory genes code for regulatory proteins and occasionally could give an example, such as those that regulate transcription. Repressible enzymes could sometimes be described as those produced all the time, but further explanation was usually lacking. Beta galactosidase could occasionally be named as an example of an inducible enzyme in the context of the *lac* operon and its synthesis occurring only when the inducer is present. Weak responses were often vague and did not go beyond what structural and regulatory genes code for.

(b) Stronger candidates explained exactly what transcription factors do and gave concise accounts of how they switch genes on and off, going on to detail their role in sex determination, responses to environmental stimuli and the regulation of cell cycles. Some candidates gave limited accounts, simply stating that transcription factors are important in gene expression.

Question 10

(a) In general, the knowledge of glycolysis and the link reaction was excellent, although frequently the defined terms for these reactions were not included. Many candidates stated that glucose is phosphorylated but did not include the role of ATP, or they described the production of ATP throughout the process but did not state the cumulative total gain. Marks could not be awarded for using the non-specific term hexose bisphosphate rather than fructose bisphosphate, confusing oxidation and reduction and describing the splitting of fructose bisphosphate into two molecules of GP instead of TP. Descriptions of the link reaction were generally accurate, and there were also some good flow diagrams that yielded marks.

(b) A generally well answered question with many candidates identifying the inner mitochondrial membrane as the site of oxidative phosphorylation. Most responses included the release of hydrogen from reduced NAD or reduced FAD, the splitting of hydrogen to protons and electrons and the movement of electrons along the ETC. While most of these went on to mention the movement of protons to the intermembrane space, a smaller number recognised that the movement of electrons released the energy required to pump these across the inner membrane into the intermembrane space. Stronger candidates were able to describe the movement of protons through ATP synthase but less frequently described the diffusion of the protons down a proton gradient back into the matrix.

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Paper 9700/43
A Level Structured Questions

Key messages

Candidates should be reminded of the differences between command words, particularly 'describe' and 'explain'. Often candidates wrote descriptions when explanations were required.

Candidates should consider the number of marks available when answering each question. This indicates the number of separate points that a candidate will need to make in order to receive full credit.

Where candidates are asked to use data provided in tables, graphs or diagrams, it is important that responses refer to the data. The data should not simply be quoted, but used to support statements, identify patterns and trends or provide evidence for conclusions, as applicable.

Successful candidates pay close attention to the wording of each question and make use of the information provided in the question contexts, integrating this with their own understanding.

General comments

Most candidates were able to demonstrate sound knowledge and understanding of the syllabus when presented with familiar contexts. Many were also able to develop effective responses in novel contexts by making links with the underlying biological principles that are embedded in the syllabus. Candidates lacking confidence when presented with unfamiliar contexts were sometimes unable to apply the relevant knowledge and understanding to engage with the assessment.

Most candidates were confident with the mathematical questions and the genetic cross. In general, **Question 1(c)(i)**, **2(c)**, **4(a)** and **5(b)(ii)** were found to be the most demanding.

Comments on specific questions

Section A

Question 1

(a) Most candidates could label an epidermal cell but parenchyma, bundle sheath and xylem cells were all mistakenly labelled as cells that contained PEP carboxylase.

(b) (i) The correct answer of bundle sheath was occasionally given but many stated mesophyll and some stated phloem or vascular bundle.

(ii) The question required a focus on anatomy, not biochemistry. Good answers showed a clear understanding of the mesophyll forming a ring around the bundle sheath cells in order to stop oxygen entering the bundle sheath cells and reacting with RuBP, so as to prevent photorespiration.

(c) (i) Candidates who read the question carefully realised that they needed only to make comparisons between two of the four lines on the graph. Candidates who gained full marks quoted figures accurately and focused on comparisons, such as the optimum temperature, the maximum rate and the change in relative uptake of C3 and C4 plants that occurred at 22 °C.

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Some candidates simply described the features of one curve and then the other. Giving the value of the maximum rate of photosynthesis in C4 plants, followed by the value for C3 plants, is not a comparison. Comparative statements include terms such as 'higher than' and 'lower than'.

Many candidates made the general statement that C4 plants had a higher rate of photosynthesis than C3 plants, even though C3 plants had a higher rate of photosynthesis than C4 plants at lower temperatures (below 22 °C). Most were able to quote data to support the difference they mentioned, and the majority quoted the full coordinates – that is, the values from both axes, with units.

(ii) Most candidates identified high CO_2 conditions as giving the higher rate. Explanations based on the idea of limiting factors sometimes omitted to state that CO_2 was limiting in low CO_2 conditions (but not in high). A few candidates compared C3 and C4 plants rather than C4 plants in the two conditions at the stated temperature range.

Question 2

(a) (i) Since all the genotypes showed a marked increase in milk yield at the second lactation, the cause was environmental, with age/maturity being the environmental variable. Many candidates did grasp this idea but few pointed out that as the change is seen in each goat in its lifetime it cannot be genetic (since each goat's genes remain the same). A few mentioned that hormones would be involved in the change.

(ii) Candidates readily described that the substitution increased milk yield, but few described the importance of that in terms of benefits to people (more food) or farmers.

(b) (i) The Hardy-Weinberg calculation was done well by many. The values of *p* and *q* had been provided so a candidate who understood the principles had fewer steps of calculation to perform. Some rounded the total down instead of up and could not be credited. Common errors were to forget to multiply by the population size (268) or to omit the 2*pq*. Some candidates mis-quoted the total number of goats as 267, with consequent effects on their final numbers of **CC** and **CG** goats.

(ii) The correct answer of chi-squared test was the commonest answer. Incorrect answers included *t*-test and Simpson's index.

(iii) Most candidates described the difference in predicted and actual numbers but fewer gave good reasons for the departure from Hardy-Weinberg equilibrium that they described. General points that could be made included migration, genetic drift and non-random mating. In view of the information provided in the question, candidates who suggested selection needed to use that information to argue that selection was acting against the heterozygotes (whose numbers were smaller than predicted) or in favour of the high-yielding **CC** goats. Mutation was not credited as the question made it clear that the mutation was a new one.

(c) Some candidates did not understand that a therapeutic recombinant protein produced in milk would be purified and given as a drug to people who lacked that specific protein. Weaker responses made reference to people drinking the milk to remedy a general protein deficiency, while stronger responses talked about treating a genetic disease. The ethical problems covered human side effects and animal welfare concerns as well as well-argued answers about vegetarian and vegan people objecting to consuming an animal product. Unspecific references to religious beliefs could not be credited.

Question 3

(a) Many candidates wrote excellent answers based on their understanding of allopatric speciation, but in the question context of subspecies (rather than species) evolving. Misspellings of geographical (e.g. geometric, geomatic) could not be credited. Those who described isolation needed to reference separation of populations (not sub-species or species) since at the initial isolation stage the birds would be fragments of one original population.

(b) Good answers to this used the information provided in the question and talked about comparison of the mitochondrial gene sequence, not alternative techniques such as genetic fingerprinting or whole genome sequencing.

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(c) The strongest answers argued that the use of a DNA barcoding device would help to catch or stop the activities of illegal traders and poachers and would prevent entry into a country of alien species that posed a threat to native endangered species.

Question 4

(a) Many answers didn't trace the essential changes from the altered amino acid to the formation of different bonds that caused adjacent haemoglobin molecules to stick together. A common error was to equate haemoglobin molecules with red blood cells and to discuss these sticking together.

(b) (i) Many candidates expressed a vague idea of more oxygen being present, preventing symptoms. A more rigorous analysis specifies that the partial pressure of oxygen in capillaries is higher, reducing HbS fibre formation and so reducing the blockage of capillaries (and associated pain) by sickled red blood cells.

(ii) The correct answer of transcription factor was commonly given. Regulatory protein was also acceptable but some candidates mistakenly described this as a regulatory gene.

(c) (i) Many candidates knew details of the process of electrophoresis but some incorrectly referred to DNA being separated, rather than the haemoglobin proteins. Strong candidates used the information given in the question to reason that HbS would travel more slowly or would move a shorter distance towards the anode.

(ii) Candidates who had followed the information given in the question were able to apply their understanding to gain two marks here.

Question 5

(a) This cross yielded full marks for many candidates. As one of the parents was homozygous recessive there was only one gamete type from that parent, simplifying the work that had to be done. Errors included not using the information in line one ('recessive phenotype for two unliked genes') to correctly work out the genotype of the cat in Fig. 5.1, not linking offspring genotypes to phenotypes and not writing out organism genotypes as diploid, with two alleles for each gene.

(b) (i) Many candidates explained that two pointed parents always give pointed offspring (i.e. the pointed characteristic breeds true), or that two full colour parents can produce a pointed offspring. Some identified that pointed individuals were always homozygous for the allele that lacked the restriction site.

(ii) Candidates struggled to express ideas about sex linkage in words and in the context of the pedigree diagram. Valid points were that the male cats on the pedigree had two copies of the DNA sequence thought to code for full colour or pointed and that sons inherited a copy from their father, or had their colour phenotype influenced by their father and not just their mother.

(iii) Some candidates correctly identified that the marker locus is inherited together with the DNA sequence that has, or does not have, the restriction site, with some identifying that in the cats on the pedigree diagram the minus (no restriction site) allele is always associated with a marker locus number of 1 – 4, while the plus (has the restriction site) allele is always associated with a marker locus number of 6 or 7. Sensible references were made to no crossing over occurring, with the strongest answers identifying that the bottom right-hand cat inherited the paternal and maternal combinations with no recombinant combinations appearing.

Question 6

(a) (i) Many candidates correctly stated the locations of the components of a cholinergic synapse. However, there was some confusion over mitochondria being in the cytoplasm of the presynaptic neurone whose membrane allowed for exocytosis of Ach when the membrane's voltage-gated channels were stimulated, and that Ach acts as the ligand that then binds to the ligand-gated channels on the postsynaptic membrane. While the swollen end of the pre-synaptic neurone allows it to be called a 'knob' this is not true of the post-synaptic neurone, though a few candidates mistakenly referred to a 'post-synaptic knob'.

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(ii) Many candidates were well-prepared and could list more than two roles of synapses in the nervous system.

(b) Good answers picked up on the question information that organophosphates inhibit an enzyme in the neuromuscular junction. They therefore followed a logical sequence of reasoning from the inhibition of acetylcholinesterase through to Ach staying bound to receptors, sodium ion channels staying open and the sarcolemma staying depolarised, giving constant muscle contraction. Weaker answers invented alternative modes of action for organophosphates that were not based on the information given in the question.

(c) Most candidates showed some knowledge of the sarcoplasmic reticulum releasing calcium ions which bind to troponin, moving tropomyosin so that actin can bind to myosin. Candidates should take care to distinguish troponin, tropomyosin and myosin by spelling these names correctly.

Question 7

(a) Most candidates gained a large proportion of the marks for matching the names of compounds and sites in cellular respiration in anaerobic conditions, with their descriptions.

(b) Candidates were generally knowledgeable about the role of oxygen breathed in to repay the oxygen debt.

Question 8

(a) Most candidates read the yields per hectare for oil palms and soya beans correctly, and divided the oil palm figure by the soya bean figure to obtain the number of hectares of soya beans that would need to be planted to give the same yield as one hectare of oil palms. Errors included calculating a percentage.

(b) Stronger candidates listed five or more reasons why it is important to maintain biodiversity.

(c) Answers that did not gain one of two marks for describing possible consumer actions often did not refer to the goal of obtaining palm oil sustainably. A suggestion that did not answer the question included consumers switching to alternative oil sources.

Section B

Question 9

(a) Candidates commonly made reference to these properties of plasmids: that they are small, circular and may contain genes for antibiotic resistance. It was rarer to see comments on their being able to replicate independently or that they consist of double-stranded DNA. Saying that they can be cut by restriction enzymes is not describing a property of a plasmid as precisely as saying that they have restriction sites. These properties were meant to be linked to the use of plasmids in gene cloning, so suggestions about their ability to travel in the body for gene therapy or their having a promoter controlling expression of an inserted gene were not relevant. Candidates did often comment on the small size being linked to ease of uptake by a host bacterium and the marker genes being useful for identifying transformed recombinant cells.

(b) The roles of the three enzymes were well-described by many candidates. The general point that restriction endonucleases cut DNA (before specifying certain sub-types of DNA like plasmids and genes of interest) was sometimes missed. Similarly, candidates sometimes made the mistake of saying that reverse transcriptase ‘converts’ mRNA into cDNA rather than saying that it uses mRNA as a template in order to construct a complementary cDNA.

Question 10

(a) The majority of candidates knew how adrenaline stimulates liver cells to convert glycogen to glucose and explained each step of the signalling cascade in relevant detail, including G protein activation, adenyl cyclase making cAMP from ATP, activation of kinase and signal amplification. A few candidates talked about glycogen or glucagon stimulating the liver cells, and some answers focused entirely on insulin and glucagon and did not answer the question with reference to adrenaline at all.

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(b) Many candidates knew the role of ABA in closing stomata in times of drought and they wrote detailed, step-by-step accounts that were logically consistent and explained the full process. Some answers made no reference to guard cells being the site of ABA binding and the subsequent changes. A common error was for candidates to call the guard cell pair the 'stoma' rather than using this name for the hole that transiently exists between them.

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Paper 9700/51
Planning, Analysis and Evaluation

Key messages

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 person to follow. However, it is not necessary to copy out all the information given in the question.

When looking for trends in data, the whole range of data should be considered and trends exemplified by qualified data quotes.

Conclusions should be more than a descriptive re-statement of the results and should be based on the trends in the data.

General comments

Candidates did not appear to be short of time and there were many good responses. The use of specific terminology was not always expressed clearly enough for credit.

Comments on specific questions

Question 1

(a) (i) This was generally well answered. The commonest error was to describe the dependent variable as mass of the pepper tissue rather than qualify this in some way to indicate change in mass. A few responses confused the dependent and independent variables.

(ii) Many candidates answered this well, often by means of a clear table, which can be the best way to explain proportional dilution. Many indicated at least 5 appropriate and evenly spaced concentrations, included units and the required volumes of 1.0 mol dm^{-3} sucrose and water to achieve them. A few used per cent as the concentration unit which is not appropriate. Just stating how one concentration was made up and then saying 'and so on' was not enough for full credit. Several responses quoted the formula $C_1V_1 = C_2V_2$ but did not make it clear what this meant. The question specifically asked for proportional dilution but a number of responses described serial dilution.

(b) There were many good responses. Candidates need to remember that it should be possible for someone to successfully implement the investigation by following their plan. Despite the instruction not to repeat the dilution information, some responses went over this in detail.

The question gave the information that pieces of pepper of known mass were prepared. It was not necessary to have them all of exactly the same mass (as that is why percentage change was going to be calculated), but to gain credit some idea of **how** they were prepared was expected. Cutting the tissue to (approximately) the same size or mass gained credit, as did references to using the same pepper, or peppers, from the same plant. Peppers of the same species is not a creditworthy point as the question tells the candidates what species was used. A clear sequence of steps in the procedure was often given. Weighing the tissues before and after submergence, placing them in the various sucrose concentrations in separate containers and ensuring that the tissue was fully submerged in the sucrose solution (or using a fixed volume of sucrose appropriate to the apparatus to ensure full submergence) all gained credit when clearly expressed. Many responses mentioned standardising the time for submergence, but unreasonably short times were often quoted, which

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suggested some lack of understanding as to how quickly water moves by osmosis. Other details which gained credit included covering the containers to prevent evaporation, the need to dry the tissue before reweighing (though not by putting in an oven as a few suggested) and details of a suitable method to keep the apparatus at a constant temperature.

The majority of candidates suggested repeating the procedure a sufficient number of times and calculating a mean. The term 'average' should not be used in a scientific context. As an investigation, it was reasonable to consider it low risk. If medium risk was suggested, the risk, hazard and mitigation must all be mentioned. Thus, there may be a risk of allergy to the tissue (the hazard) and the mitigation is suitable protective clothing like goggles or gloves. A number of candidates suggested allergy to sucrose solution which did not gain credit. Similarly, there may be a risk of cutting oneself as scalpels (the hazard) are used. Here the mitigation is to cut away from yourself, not just 'be careful'.

(c) (i) There were two parts to this question. The second part on the reason for calculating the percentage change was sometimes missed. Where it was attempted, some answers were rather generalised in terms of 'comparing results.' This needed qualification in terms of the likelihood that the starting masses of the tissue would vary or the comparisons would be more valid. Candidates were generally clear on how to calculate percentage change. Errors included not multiplying by 100 or using the final mass as the denominator in the formula. Candidates should be aware that in this context the tissues would have either gained or lost mass depending on the concentration of the sucrose solution and thus the resulting value could be negative or positive.

(ii) There were some clear and appropriate answers which were awarded full credit, but also some confusion. The *x*-axis was nearly always correctly labelled as sucrose concentration and only occasionally had missing or incorrect units. Where the *y*-axis was correctly labelled as percentage change in mass, most responses showed a downward trend from left to right with the line intersecting the *x*-axis at some point. A few lines showed an incorrect trend, rising from left to right, a u-shaped plot intersecting the *x*-axis twice or a plot never crossing the *x*-axis. Identifying the intersection point as the sucrose concentration equivalent to the water potential of the tissue was not always indicated by some form of label or annotation. A significant number of responses identified the *y*-axis as the water potential. This was inappropriate as sucrose concentration and water potential are two aspects of the same data.

(d) (i) This was correctly answered by many candidates, though a few did not give units or missed the minus sign. Unlike the method that they designed their investigation for, this method was likely to be less familiar and therefore careful reading of the information was needed. A few described how to find the water potential in general terms rather than answering what the question actually asked, which was to look at the results in **Fig. 1.4** and relate them to the data in **Table 1.1** and thus give a numeric answer.

(ii) There were good answers making clear positive statements as to why method 1 was likely to give a better estimate of the water potential, or why method 2 would not. Method 1 is objective and quantitative and gives numerical values which can be plotted graphically whilst method 2 is more subjective and qualitative. Some responses gained credit for the idea that it was difficult to place the drop consistently at the start, or that the drops might disperse. A number of responses confused seeing the movement of the drop being difficult, with judging by eye the point to which the drop had moved. Many responses had rather general references to method 1 being simpler to follow rather than focussing on clear positive statements. Mentioning the possible variation in size of the drop in method 2 was not creditworthy – it is the density of the solution in the drop that is the deciding factor on the level to which it moves.

Question 2

(a) (i) Several candidates were able to suggest two or three correct answers. Required features of the line transect (length, sampling intervals, and quadrat size used at the sampling intervals), were often correctly suggested. Time of year or season for sampling was also credited, although reference to the time of day was also seen and is not valid in the context of the described investigation. Generalised references to the environment and the area or location were not creditworthy, but there were some responses which gave a clear idea of orientating all transects in the same direction. References to red quinine trees, or plant species needing to be standardised were quite commonly seen. These were the variables being investigated and therefore to describe them as ones to be standardised showed the candidate had not understood the aim of this study.

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(ii) Many candidates correctly described the use of some form of random number generator (on a calculator, mobile phone or app). This would be used in the context of selecting where the 14 sites would be placed. Many elaborated on this by correct reference to using the numbers generated in conjunction with coordinates. Some responses were confused as they described using the randomly generated numbers to number each of the 14 sites which had already been marked out on the ground – missing the point of intentionally deciding where to put the sampling plots.

(b) Many candidates were able to correctly identify that 'the number of individuals of **each** species' needed to be found in order to calculate Simpson's index of diversity (and from this, the **total** number of **all** individuals in **all** species combined can be calculated to use in the formula). Unqualified references to the 'number of species' or to the 'number of plants/red quinine trees' did not gain credit. This was a situation where the answer needed clear wording using appropriate terminology.

(c) There were many correct answers of 185.7 or 186. Some candidates incorrectly rounded their final answer or used the wrong denominator in the calculation.

(d) There were some good answers here, but many found it difficult to express their ideas in a clear way. Some responses only referred to **Fig. 2.1** and others only to **Table 2.1**. Answers covering both were required. The evaluation needed to indicate the degree of support, or otherwise, provided by the data. In Fig. 1.1, it can be seen that the increase in red quinine tree cover is accompanied by a drop in ground cover by other plants (and an increase in bare ground with no plants) from 1998–2003. Therefore, there seems to be a correlation which may indicate a decrease in species diversity – supporting the hypothesis. That is backed up by the *p* value from Table 2.1. A value of < 0.001 for that time period indicates the relationship is significant (biologists accept *p* values below 0.05 as significant). Many candidates seemed confused here and suggested that the *p* value of < 0.001 showed that the relationship was not significant. Very few candidates appreciated that the changes between 2003 and 2005 also support the hypothesis. The changes during this period were very slight in both red quinine trees and other plant species, and the value of $p = > 0.05$ indicates such changes are not significant. This supports the hypothesis, as with no significant change in red quinine values, there is no significant change in species density. There is a correlation, but this does not necessarily mean it is a causal relationship. Other factors might be involved the drop. Concluding and evaluating using relatively complex, but limited data, is a skill that can be developed by practice.

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Paper 9700/52
Planning, Analysis and Evaluation

Key messages

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 person to follow. However, it's not necessary to copy out all the information given in the question.

When looking for trends in data, the whole range of data should be considered and trends exemplified by qualified data quotes.

Conclusions should be more than a descriptive re-statement of the results and should be based on the trends in the data.

General comments

Candidates did not appear to be short of time and there were many good responses. The use of specific terminology was not always expressed clearly enough for credit.

Comments on specific questions

Question 1

(a) Many candidates correctly identified that the stalk cells became turgid or described this by stating that they contained water and were enlarged or expanded. The question asked about the cells of the stalk, therefore those candidates who just made reference to the stalk or the flower could not gain credit. Candidates needed to conclude that it was the cuticle that was waterproof, or reduced water loss, rather than the epidermis. Some candidates referred to the fact that the xylem provided mechanical support which was credited.

(b) (i) The question asked how a range of solutions could be made by proportional dilution of the 1.0 mol dm^{-3} sucrose solution. Many candidates described how to make a range of solutions using a serial dilution method and therefore were not able to gain full credit. A minimum of five different concentrations were required and these also needed to be evenly spaced. Candidates that presented their answer as a table were likely to gain high marks. It was common for responses to include the volumes of 1.0 mol dm^{-3} and water but not go on to state the concentration this would make, and therefore did not gain credit.

(ii) Many candidates correctly identified the independent variable as the sucrose concentration and the dependent variable as the curvature or bending of the strip.

(iii) There were many clear and detailed plans which gained full credit. Weaker responses tended to just copy out the basic procedure. There were a number of candidates who spent time repeating how they would make up their sucrose solutions. As stated in the question, this was not required as this skill was assessed in the previous question. Many candidates added details such as volumes of sucrose solution, rather than just stating that they would standardise these. Many candidates also gained credit for describing a method for maintaining a constant temperature.

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 centres should encourage their candidates to use this terminology as a matter of course.

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Safety issues should be specific to the investigation or an assessment made of the risk. This investigation was low risk. Credit was given to responses which correctly identified that some people could be allergic to the plant and should therefore wear gloves, or that when using a scalpel you may cut yourself and therefore you should cut away from your hand. A few candidates just referred to being careful when using a scalpel and this was insufficient to gain credit.

(c) (i) Many candidates were able to correctly label sucrose concentration on the *x*-axis. Fewer candidates were able to correctly label the *y*-axis with the degree or angle of curvature. Candidates should be encouraged to use the information provided in the question when labelling axes. Some candidates omitted units and therefore were not able to attain full credit. The majority of candidates were able to sketch a graph to show the expected result. Candidates needed to indicate how the graph could be used to estimate the sucrose concentration equivalent to the water potential of the tissues in the flower stalk. Many candidates missed this part of the question, highlighting the importance of reading the question carefully.

(ii) Candidates needed to state clearly that the strip would not curve, or it would remain straight, to be awarded the mark. Many responses just referred to the strip not changing, or remaining the same, which was not correct. The information at the start of the question stated that the strip immediately curved when cut, therefore, if the strip remained the same, it would be curved, which was incorrect.

Question 2

(a) (i) Candidates were asked to explain the reason for spraying the water hyacinth plants with insecticide in treatment 3. In order to gain credit, candidates needed to state that the treatment was to see the effect on the number of feeding scars or the length of the petiole. Some candidates gained credit for stating that treatment 3 could have also been used to remove any weevils which remained on the water hyacinth plants after the initial 6 weeks.

(ii) Many responses as to why treatment 2 was included in the experiment were too generic. Candidates needed to be precise in their answers and refer to the information provided in the question**.** Answers explaining that treatment 2 was to see the effect on the number of scars, or the petiole length caused by the weevils, gained credit. Those responses which just referred to seeing the effect of the weevils did not gain credit.

Candidates scored better when explaining the reason why treatments 4, 5, and 6 were included in the experiment. Answers discussing that it was to see how long the insecticide remained active, or how effective the insecticide was over time, gained credit.

(iii) Many responses correctly referred to the standard deviation showing the spread of data around the mean. Candidates also needed to identify if the standard deviations overlapped, or not, and what that meant in terms of there being a significant difference between the means. A few candidates correctly identified that if there was no overlap of standard deviations then this suggested that there *may be* a significant difference. Those candidates who stated this meant that there *was* a significant difference so did not gain credit, since this could only be concluded if further statistical analysis was carried out.

(iv) Candidates were asked to state **one** conclusion that could be made from the results provided. There were a variety of answers seen. Amongst the most common to gain credit was that the insecticide killed the weevils, or that the insecticide reduced the number of scars seen on the water hyacinth. A number of candidates incorrectly stated that the mean length of the longest petiole decreased. When the standard deviations were considered, this was not correct due to their overlapping in all groups.

(b) (i) Many candidates were able to calculate the percentage change correctly, with many also rounding their answer correctly. The most common mistake was to choose the incorrect denominator.

(ii) Most candidates were able to correctly state that the reason the *t*-test could be used to analyse the data was that the data was comparing two means, was continuous, or the data would have a normal distribution. The most common incorrect answer was that the data was discrete.

(iii) Stating the formulae needed to calculate the degrees of freedom without further qualification was commonly seen. This did not gain credit as the question asked what information was needed to

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calculate this. Those candidates who clearly stated that the number of plants sampled before treatment **and** the number of plants sampled after treatment was needed gained credit. An alternative way of attaining the mark was to state that the number of plants sprayed **and** the number of plants not sprayed was needed. Many candidates who referred to the number of plants did not make it clear that these two different pieces of information were needed.

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When looking for trends in data, the whole range of data should be considered and trends exemplified by qualified data quotes.

Conclusions should be more than a descriptive re-statement of the results and should be based on the trends in the data.

General comments

Candidates did not appear to be short of time and there were many good responses. The use of specific terminology was not always expressed clearly enough for credit.

Comments on specific questions

Question 1

(a) (i) This was generally well answered. The commonest error was to describe the dependent variable as mass of the pepper tissue rather than qualify this in some way to indicate change in mass. A few responses confused the dependent and independent variables.

(ii) Many candidates answered this well, often by means of a clear table, which can be the best way to explain proportional dilution. Many indicated at least 5 appropriate and evenly spaced concentrations, included units and the required volumes of 1.0 mol dm^{-3} sucrose and water to achieve them. A few used per cent as the concentration unit which is not appropriate. Just stating how one concentration was made up and then saying 'and so on' was not enough for full credit. Several responses quoted the formula $C_1V_1 = C_2V_2$ but did not make it clear what this meant. The question specifically asked for proportional dilution but a number of responses described serial dilution.

(b) There were many good responses. Candidates need to remember that it should be possible for someone to successfully implement the investigation by following their plan. Despite the instruction not to repeat the dilution information, some responses went over this in detail.

The question gave the information that pieces of pepper of known mass were prepared. It was not necessary to have them all of exactly the same mass (as that is why percentage change was going to be calculated), but to gain credit some idea of **how** they were prepared was expected. Cutting the tissue to (approximately) the same size or mass gained credit, as did references to using the same pepper, or peppers, from the same plant. Peppers of the same species is not a creditworthy point as the question tells the candidates what species was used. A clear sequence of steps in the procedure was often given. Weighing the tissues before and after submergence, placing them in the various sucrose concentrations in separate containers and ensuring that the tissue was fully submerged in the sucrose solution (or using a fixed volume of sucrose appropriate to the apparatus to ensure full submergence) all gained credit when clearly expressed. Many responses mentioned standardising the time for submergence, but unreasonably short times were often quoted, which

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suggested some lack of understanding as to how quickly water moves by osmosis. Other details which gained credit included covering the containers to prevent evaporation, the need to dry the tissue before reweighing (though not by putting in an oven as a few suggested) and details of a suitable method to keep the apparatus at a constant temperature.

The majority of candidates suggested repeating the procedure a sufficient number of times and calculating a mean. The term 'average' should not be used in a scientific context. As an investigation, it was reasonable to consider it low risk. If medium risk was suggested, the risk, hazard and mitigation must all be mentioned. Thus, there may be a risk of allergy to the tissue (the hazard) and the mitigation is suitable protective clothing like goggles or gloves. A number of candidates suggested allergy to sucrose solution which did not gain credit. Similarly, there may be a risk of cutting oneself as scalpels (the hazard) are used. Here the mitigation is to cut away from yourself, not just 'be careful'.

(c) (i) There were two parts to this question. The second part on the reason for calculating the percentage change was sometimes missed. Where it was attempted, some answers were rather generalised in terms of 'comparing results.' This needed qualification in terms of the likelihood that the starting masses of the tissue would vary or the comparisons would be more valid. Candidates were generally clear on how to calculate percentage change. Errors included not multiplying by 100 or using the final mass as the denominator in the formula. Candidates should be aware that in this context the tissues would have either gained or lost mass depending on the concentration of the sucrose solution and thus the resulting value could be negative or positive.

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