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Paper 9700/11
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Question 1

More than half of all candidates answered this question correctly. The weaker candidates found this difficult, with a fifth of being wrong by a factor of ×100 and over half being wrong by a factor of ×10.

Question 2

More than half of the weaker candidates realised that the magnification would remain the same but nearly two fifths of them incorrectly thought that the resolution would decrease.

Questions 3, 10, 17, 18, 19, 21, 22, 33, 35 and 36

Most candidates answered these correctly.

Question 4

More than half of all candidates answered this question correctly. Over half of the weaker candidates incorrectly thought that the Golgi body and lysosomes contained nucleic acid.

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Questions 5, 26 and 27

Nearly half of all candidates answered this question correctly, with the weaker candidates selecting each option almost equally.

Questions 6, 8, 24, 28, 29 and 40

More than half of all candidates answered these correctly.

Question 7

Almost half of all candidates incorrectly selected **A** or **D**. The Benedict's test shows the presence of reducing sugars, it cannot determine the particular reducing sugar.

Questions 9, 11, 14, 15, 34, 37 and 39

Almost half of all candidates answered these correctly.

Question 12

Most of the stronger candidates correctly multiplied the number of molecules by 2, since each molecule has 2 α-globin chains.

Question 13

Most candidates knew that statements 2 and 4 were correct, two fifths incorrectly thought that statement 3 was correct.

Question 16

Over half of all candidates incorrectly though that statement 1 was correct. The shape would not be the same, it would be complementary in order to fit into the receptor.

Question 20

Over half of all candidates knew that adenine would pair with a single ring base. Just over a third reasoned that the pentose sugar would be deoxyribose so would have a 5 : 4 ratio of carbon to oxygen atoms.

Question 23

Nearly half of all candidates answered correctly. Many candidates did not appreciate the role of hydrostatic pressure in the xylem.

Question 25

Most of the stronger candidates answered correctly but less than a fifth of the weaker candidates answered correctly. Two fifths of the weaker candidates incorrectly selected the xylem.

Question 30

Most candidates answered incorrectly. Candidates should be aware that blood pressure decreases as blood flows from an artery to the capillaries and then a vein. Therefore, only options **A** or **D** needed to be considered. The blood pressure in the right atrium is very low as it is filled from a vein and only needs to move blood to the ventricle. Therefore, **A** is correct.

Questions 31 and 32

Nearly half of all candidates answered these correctly.

Question 38

Nearly half of all candidates were not aware that T-lymphocytes produce toxins. These are used by killer T cells.

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Paper 9700/12
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Questions 1, 9, 11, 18, 21, 23, 24, 25, 27, 28, 33 and 40

More than half of all candidates answered these questions correctly.

Questions 2, 5, 6, 7, 10, 20, 35, 36 and 37

More than half of all candidates answered these questions correctly.

Question 3

Many of the weaker candidates answered this incorrectly as they did not recognise that vesicles can bud off the endoplasmic reticulum in order to form the Golgi body.

Question 4

Over half of all candidates could evaluate the information provided.

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Question 8

More than half of all candidates answered this correctly.

Question 12

Most candidates found this question very difficult. The incorrect statement is **A**. The shape of the sucralose molecule would no longer be complementary to the active site of sucrase.

Question 13

Over a half of all candidates answered this correctly.

Question 14

Nearly half of all candidates answered correctly. Over a third of the remaining candidates incorrectly selected option **D**.

Question 15

More than half of all candidates answered this correctly.

Question 16

Nearly half of all candidates answered this correctly. However, over four fifths of the weaker candidates selected options which included statement 1. This statement cannot be correct since the membrane is permeable to monosaccharides and water. Sucrose is a disaccharide so will not move in or out of the model cell.

Questions 17 and 19

More than half of all candidates answered this correctly.

Question 22

Whilst more than half of stronger candidates could evaluate the information provided, less than a fifth of the weaker candidates could do this.

Question 26

More than a half of the weaker candidates answered this incorrectly, less than a half incorrectly selecting options that did not include the hydrostatic pressure gradient. Almost one fifth of the weaker candidates did not think that ATP was required.

Question 29

More than half of the weaker candidates incorrectly believed that all three gases can combine with the haem group in haemoglobin.

Questions 30 and 31

Less than half of all candidates were able to answer these two questions correctly.

Question 32

More than half of all candidates did not show understanding that squamous epithelium in the gas exchange system is only found in the alveoli. The ciliated epithelium in the trachea and bronchus is columnar.

Question 34

More than half of all candidates answered correctly.

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Question 38

More than half of the stronger candidates answered correctly. Most of the weaker candidates were unable to determine that the reason cancer cells can be targeted is because they have different antigens from normal cells.

Question 39

Whilst most candidates selected options that included statement 3 (the only correct statement), over half of these candidates also thought that statement 1 or statement 2 was also correct.

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Paper 9700/13
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Questions 1, 15 and 31

Most of the stronger candidates answered these correctly, whilst more than half of the weaker candidates incorrectly selected a different option.

Questions 2, 3, 4, 7, 19, 20, 25 and 35

More than half of all candidates answered these correctly with at least three quarters of the stronger candidates and at least a third of the weaker candidates choosing the correct answer.

Questions 5, 26, 30 and 39

Most of the stronger candidates answered correctly, whilst the weaker candidates selected each option almost equally.

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Questions 6, 11, 14, 17, 18 and 33

Most of the stronger candidates answered correctly and about a fifth or less of the weaker candidates answered these questions correctly.

Questions 8, 9, 10, 12 and 24

At least half of all candidates answered these questions correctly.

Question 13

Many of the weaker candidates incorrectly selected options where the quaternary structure described was like that of haemoglobin. They did not consider that the question was about proteins in general and that the quaternary structure of proteins is extremely varied.

Question 16

Less than a third of all candidates answered correctly. When comparing the blocks, the block with the overall smallest dimension on one or more sides would become colourless most quickly. In this case block **A** has a thickness of 3 mm, therefore the acid only has to diffuse 1.5 mm in order to enter the whole block.

Question 21

Only a third of all candidates correctly realised that bonds between complementary bases would break once to expose the DNA template strand and once to separate the transcript RNA from the DNA. Complementary bonds also form once as the two DNA strands re-join and once as the RNA transcript binds to the DNA strand.

Questions 22 and 36

More than half of all candidates answered these two questions correctly.

Question 23

More than half of the weaker candidates did not realise that the α-globin would be coded for by one gene as would the β-globin. Each gene would allow many copies of each globin to be formed.

Question 27

The movement of phloem contents to a source and the changes in the water potential and volume of liquid remaining in the phloem sieve tube element were not understood by nine tenths of the weaker candidates.

Question 28

Most of the stronger candidates answered this correctly. However, over three fifths of the weaker candidates incorrectly thought that the diffusion of hydrogen ions into companion cells was the first process in the sequence.

Question 29

Whilst most stronger candidates found this question very easy, over three quarters of weaker candidates answer incorrectly.

Question 32

Less than a third of all candidates answered this correctly. Almost two fifths of all candidates did not appreciate that glucose would be found in all blood vessels, lymph, and tissue fluid.

Question 34

Almost two thirds of all candidates incorrectly selected options that indicated that cartilage is present in terminal bronchioles.

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Question 37

Over a third of all candidates incorrectly selected the answer measles. Measles is a viral disease and transmission would not be reduced by antibiotic therapy.

Question 38

A third of all candidates answered this question correctly. The pathogens of malaria and TB are both living organisms with a cell surface membrane and ribosomes as well as genes. The pathogen causing AIDS is a virus and will only have genes.

Question 40

Over two thirds of all candidates incorrectly selected options including statement 2. This statement does not describe the formation of hybridoma cells.

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Paper 9700/21
AS Level Structured Questions

Key messages

Candidates should distinguish carefully between questions that ask for descriptions of the data and those that ask for explanations. **Question 3(a)** asked for an explanation of the results shown in **Table 3.1**, and a full answer to **Question 3(b)** required both a description and an explanation. If a question asks for a description and an explanation then both are required to achieve full credit.

Some data tables and graphs show linear relationships that can be described as '*y* increases as *x* increases'. However, the data in the table and graph in **Question 3** cannot be described like this. Candidates need to develop skills in describing the data associated with investigations of the effects of osmosis on non-living and living systems.

Candidates should know the type of organism that causes each of the infectious diseases listed in the syllabus. In **Question 5**, some candidates described the causative organisms of malaria as a virus or a bacterium, rather than as a protoctist.

General comments

Candidates who wrote good answers often highlighted key information in the stems of the questions. This helped them to process the details provided. They also often underlined the command words which seemed to help them focus on the type of answer required.

Knowledge of the syllabus content was varied, with many showing confidence in all the syllabus topics. Others needed to improve their overall knowledge and/or skills in analysing and interpreting data.

Modern biological sciences use many concepts from the physical sciences. These concepts include: molecules, atoms, ions and electrons; acids, bases, pH and buffers; and hydrolysis and condensation. Use of these concepts was required in **Question 2**, **Question 4(c)** and **Question 6(e)** in this paper.

Some candidates did not recognise that acid hydrolases and carbonic anhydrase are enzymes. Some did not realise that the question on carbonic anhydrase referred to transport of carbon dioxide in mammals. Candidates should ensure that they recognise terms used in the syllabus. Some candidates could have improved their responses by using the correct biological terminology. For example, in **Question 3**, the phrase 'concentration of water' appeared in many answers. References to 'hypotonic' and 'hypertonic' in answers to **Questions 3(a)** and **(b)** were ignored as candidates are expected to use water potential terminology when explaining results of investigations of osmosis in living and non-living systems.

Candidates often benefited from annotating trends and patterns shown in the tables and graphs before attempting to answer the question. Candidates should use the information and/or data from tables and graphs in their answers, stating values with units. They should avoid vague references to the data, such as 'at a high concentration'. Descriptions of data should be precise. Candidates often wrote 'approximately' or 'about' instead of giving figures taken from **Fig. 3.2**. Units were not always given and resulted in loss of credit.

It was clear from many scripts that candidates had read through their answers and had made some changes that led to improvements. Other scripts included obvious contradictions that could have been spotted if candidates had taken time to check their answers. In **Question 3(b)**, some candidates wrote that red blood cells burst because they have no cell wall and then stated that water moves across the cell wall into the cell.

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When checking their answers, candidates should read the question again to make sure that they have not deviated from the requirements. Many often wrote correct but irrelevant material. **Question 4(c)** was an example as many wrote about the transport of oxygen instead of the transport of carbon dioxide. Candidates should not offer a choice between two or more answers as happened in some scripts. If only one answer is required, then any alternatives will not gain credit.

Candidates are advised to avoid using abbreviations such as 'bc' ('because') or arrows pointing up, down or sideways to indicate an increase, decrease or no change.

Comments on specific questions

Question 1

(a) Many candidates gave the formula for calculating the actual width of the cell in **Fig. 1.1**. Many showed their working clearly and expressed their answers to one decimal place. Some candidates needed to measure the width of the cell more carefully, convert centimetres to micrometres correctly, and many needed to round their answers to one decimal place.

(b) (i) There were many candidates who correctly identified all four cell structures. **E** (cellulose, within the cell wall) was misidentified by some. **D** (cytoplasm), rather than **A** or **B**, was a common choice for histone proteins.

(ii) Most candidates identified chloroplasts or mitochondria. The nucleus was given on many scripts.

(iii) mRNA is produced in the nucleus and also in chloroplasts and mitochondria. Some candidates gave the nucleolus as their answer. This structure produces ribosomal RNA rather than mRNA. Endoplasmic reticulum, ribosomes and cytoplasm were other structures given. RNA polymerase was also seen.

(c) Stronger responses referred to the high resolution of the image and gave an example of a structure that would only be seen in a transmission electron micrograph. The internal structures of chloroplasts and mitochondria were mentioned by many, although more named thylakoids than named cristae. Some made vague references to details visible without naming specific structures. Some misinterpreted the question and explained why the image was a scanning electron micrograph. There were some good explanations that dealt with magnification. A common mistake was to refer to the image being in black and white, which was inappropriate in this context as electron micrographs often have false colours added and photomicrographs can be printed in black and white.

Question 2

(a) Candidates were asked to describe the hydrogen bonding shown in **Fig. 2.1**. Answers should include some features that were visible in the diagram together with knowledge of hydrogen bonding. Some answers were most impressive, showing a sound understanding of the dipolar nature of water molecules. Some candidates needed to give clearer answers, with many showing confusion between covalent and hydrogen bonding and between hydrogen ions and the hydrogen atoms that compose each molecule of water. Some misused the word 'molecules' to describe hydrogen and oxygen atoms within water or thought that individual hydrogen bonds were strong. Also, some referred to cohesive forces contributing to hydrogen bonding. There was no credit for descriptions of the role of hydrogen bonds in the transport of water in xylem.

(b) (i) The role of hydrogen bonding in the secondary structure of proteins was understood by many who made it clear that hydrogen bonds are involved in stabilising alpha-helices and beta-pleated sheets. Credit was not awarded to those who stated that hydrogen bonds occur between polypeptides or those who referred to 'a helix' or 'a pleated sheet'.

(ii) Most candidates stated that hydrogen bonds help to maintain the 3D or globular structure of the protein. Some answers dealt with all the bonds that stabilise the tertiary structure rather than concentrating on hydrogen bonding or referred to quaternary structure. Some candidates made the distinction between the secondary structure of proteins and referred to the 'further folding of a polypeptide' to form the tertiary structure, often explaining that the hydrogen bonds form between

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R-groups. Good answers went on to give the detail that these form between –NH and –CO or –OH groups. Many stated incorrectly that the hydrogen bonds in tertiary structure are strong bonds.

(c) This question was about the solvent action of water and the strongest responses focused only on this, rather than describe the importance of other properties of water. Many answers explained that ions and polar molecules dissolve in water and are transported through plants, although many did not state both in their answers. Most candidates gave names of polar molecules, usually sucrose and amino acids. Some stated incorrectly that glucose is the main sugar transported in phloem rather than sucrose. A number of candidates thought of other examples, such as the storage of water-soluble substances in cell vacuoles, the metabolic reactions that occur within water in cells and the absorption of gases (carbon dioxide and oxygen) at cell surfaces.

Some candidates were very confused about xylem and phloem in terms of their roles in transport. Many candidates missed the point of the question, giving details of transpiration and describing other properties of water, such as acting as a reagent in hydrolysis reactions and in photosynthesis.

Question 3

(a) There was some evidence of candidates processing the data by annotating **Table 3.1** before answering the question, which is good practice. There were many good answers to this question, which used the concept of water potential to explain the movement of water out of and into the filled pieces of Visking tubing. The explanations were related to the results obtained, making it clear that water moved out of the tubing that contained the 0.0, 0.4 and 0.8 mol dm^{-3} sucrose solutions and moved into the tubing that contained the 1.2, 1.6 and 2.0 mol dm^{-3} sucrose solutions. A few candidates correctly referred to the net movement of water. A common error was to describe a simple linear relationship between the two variables shown in **Table 3.1**. Many wrote: 'as the concentration of sucrose increases so the increase in height of meniscus increases'. Some stated that water moved down a concentration gradient and often became very muddled because they referred to concentrations rather than using water potential terminology. Some candidates used the term 'tube' for Visking tubing, forgetting that the Visking tubing was placed in a test-tube, and this meant that it was not always possible to be sure that the explanation given was correct. Some made correct statements about the circumstances in which water would enter or leave the Visking tubing but did not make clear which results they were explaining. Despite being told that the Visking tubing was not permeable to sucrose, some candidates wrote about the diffusion of sucrose into and out of the tubing.

(b) This question on the effect of immersing red blood cells in solutions of different concentration also attracted some very well-written answers. These candidates divided the graph into three sections, stating that all the red blood cells in the samples immersed in solutions between 0.00 and 0.04 mol dm^{-3} sodium chloride burst. They then stated that the percentage of cells that burst decreased between 0.04 and 0.14 mol dm^{-3} and that between 0.14 and 0.24 mol dm^{-3} none of the red blood cells burst. Good answers explained the reason for bursting in terms of water potential gradients into the cells and the lack of cell walls to resist the increase in intracellular volume or pressure. It was more difficult to know at exactly which concentration of sodium chloride there was no net movement of water by osmosis between the solution and the red cells, so some leeway was allowed for explanations of the results between 0.14 and 0.24 mol dm^{-3}. Some candidates did not link their explanations clearly to the different ranges of concentration, often describing the events occurring at a specific concentration. Weak answers often started by giving a description of the relationship as if it were linear: 'The percentage of red blood cells that burst decreases as the concentration of sodium chloride increases' was not precise enough. Some candidates misinterpreted the data stating that 100% of red blood cells remained intact at 0.00 – 0.04 mol dm^{-3}.

Question 4

(a) Many candidates gave good explanations of the induced-fit hypothesis of enzyme action, although some descriptions of the lock and key model were seen. Some did not make it clear that the active site of the relevant enzyme does not have a shape that is complementary to its substrate molecule. There were candidates who used the terms 'similar' or 'matching' instead of 'complementary'. Most explained that the active site changes shape so that an enzyme-substrate complex can form. Some suggested that the substrate changed shape, and some referred only to the enzyme changing shape rather than to the active site. A few went on to state that once in the active site the activation energy is lowered. A common error was referring to the substrate leaving the enzyme

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following the reaction, rather than the product. Some candidates misread the question and wrote about enzyme inhibition.

(b) (i) **Fig. 4.1** showed the effect of increasing substrate concentration on the initial rate of reaction catalysed by peroxidase isolated from radish plants. Stronger answers referred to the substrate concentration as the limiting factor for the 'slope' and enzyme concentration as the limiting factor for the 'plateau' shown in **Fig. 4.1**. Candidates also referred to the increase in collisions between substrate and active site and the availability of active sites at concentrations up to 0.35 mmol dm^{-3} and the saturation of active sites at concentrations greater than 0.35 mmol dm^{-3}. Weaker responses tended to describe the pattern shown in **Fig. 4.1** and offered no explanation. Some candidates interpreted the graph as showing the progress of a single reaction mixture, explaining that the reaction stops after a while because all the substrate has been broken down. Some candidates referred to enzymes or substrates being limiting, not mentioning their concentrations. A few candidates made incorrect reference to the 'plateau' being due to the enzyme being denatured. Many incorrectly stated that the enzyme was 'used up' so that the reaction came to a stop.

(ii) Almost all of the candidates described how the value of K_m was determined for peroxidase. Some used intercepts on **Fig. 4.1** to show how the values of V_{max} and K_m were derived. Labelled intercepts would have made the descriptions clearer in many cases. A few candidates referred to the highest rate occurring at 0.2 mmol dm^{-3} and took K_m as half of that.

(c) Many candidates could have improved their answers by going into greater detail for this question on the role of carbonic anhydrase in the transport of carbon dioxide. Many described the reaction between carbon dioxide and water and needed to explain that the carbonic anhydrase that catalyses this reaction is in red blood cells. Most stated that carbonic acid dissociates to form hydrogen ions and hydrogen carbonate ions, although those who gave a formula for hydrogen carbonate often wrote CO_3^- or HCO_3. Other incorrect forms of hydrogen carbonate ions given were HCO2 and HCO^-. A number of candidates indicated that the hydrogen carbonate ions move out of red blood cells into the plasma; some correctly described this as facilitated diffusion or diffusion through a transport protein. Many simply stated that about 80% of carbon dioxide is transported in the 'blood' without being more specific. Candidates should also know that carbonic anhydrase is one of the fastest known enzymes which helps maintain a steep concentration gradient for carbon dioxide so the blood can transport large quantities of this waste from respiration. Some suggested that carbonic anhydrase breaks down carbon dioxide to 'simpler molecules making it easier to transport'. Many answers focused on the fate of the hydrogen ions rather than the hydrogen carbonate ions. A few attempted to answer from the point of view of carbonic anhydrase in plant cells, which is not on the syllabus.

Question 5

(a) Most candidates stated that mosquitoes are responsible for the transmission of malaria. Some of these needed to add that the female *Anopheles* mosquito is the vector of the disease. Many described the uptake of blood from infected people. It is not accurate to state that transmission is the result of a mosquito 'bite'. The strongest responses described the injection of saliva containing anticoagulant and the infective stage of *Plasmodium*, when the vector takes a blood meal from an uninfected person. Some candidates stated incorrectly that the pathogen is a virus or a bacterium.

(b) The flow chart showing the production of monoclonal antibodies was completed successfully by most candidates. Common errors included stating T-lymphocytes (or T-cells) or not specifying the type of lymphocyte, using the term 'bind' instead of 'fuse' and naming the cell formed as 'memory' rather than 'hybridoma'. Hybridoma was not always spelled correctly.

(c) There were many good answers to this question on the advantages of test strips for malaria. Fast diagnosis, accurate results, low cost and ease of use were common answers. Some candidates gave concisely worded answers detailing their reasoning. For example, they explained that specialised equipment is not needed so that trained staff are not required to administer the tests. Some candidates stated correctly that treatment could be started as soon as a positive test result was seen. Fewer realised that greater access to these strips means that anti-malarial drugs do not have to be used 'just in case' to prevent people becoming infected with *Plasmodium*. Some candidates gave answers that repeated information given in the question stem.

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(d) Most candidates referred to the tropics or to the climate in tropical areas where malaria is found to answer this question. A number answered from the perspective of the prevalence of malaria in different parts of the world and could have improved by concentrating on the parts of the world where people are at risk of this disease. Candidates did not always make clear which environmental factors favour *Anopheles* mosquitoes and which favour the development of *Plasmodium*. Candidates should appreciate that *Plasmodium* completes its life cycle in mosquitoes that have a body temperature that fluctuates with the ambient temperature. Some candidates referred to 'malaria' as the pathogen rather than to *Plasmodium.* Many appreciated that *Anopheles* mosquitoes need bodies of stagnant or still water to breed. Other factors that were considered included resistance of the vector to insecticides and resistance of *Plasmodium* to antimalarial drugs. In some areas, malaria has been introduced to previously uninfected populations by migrants from areas where malaria is endemic. The inability of governments and/or health authorities to control malaria was rarely explained, although examples of suitable control measures that should be used were often given. Incorrect factors that were given included sickle cell anaemia and transmission through drinking water. There were a few vague references to antibiotics which did not gain credit. Some candidates knew that the antibiotic doxycycline is used as a prophylactic drug for malaria.

Question 6

(a) Most candidates identified **A** as rough endoplasmic reticulum and **E** as the Golgi body. A common error was to identify **E** as smooth endoplasmic reticulum. Candidates should recognise the command word 'name' and avoid using letters or abbreviations, such as RER.

(b) Many candidates gave descriptions of the functions of lysosomes. The vesicles shown transfer polypeptides from rough endoplasmic reticulum to the Golgi body. The direction of transfer was required for credit to be awarded.

(c) Almost all candidates identified the process as endocytosis or phagocytosis. Some candidates gave diffusion or active transport.

(d) Most answers described the role of lysosomes in digesting bacteria. Quite a large number also explained that worn-out organelles, such as mitochondria, are also broken down by acid hydrolases from lysosomes. Fewer candidates gave the names of substrates for the acid hydrolases or stated that the end products of the breakdown can be used in the cell. There were many answers referring to the digestion of 'worn-out cells' rather than breakdown of organelles. Others stated that the 'acids' were destroying the bacteria, without appreciating that acid hydrolases are enzymes.

Some made errors transferring the information in the diagram and thought that the bacteria were shown in **B** and the mitochondrion in **D**. Stronger candidates included antigen presentation in their answers.

(e) There were many good answers explaining that hydrogen ions are pumped into lysosomes against a concentration gradient by active transport. Further detail of the action of carrier proteins was often included. However, many candidates did not realise that a low pH means that the contents of lysosomes are acidic and have a high concentration of hydrogen ions. Many candidates stated that hydrogen ions are moved out of lysosomes.

(e) There were many good answers explaining that hydrogen ions are pumped into lysosomes against a concentration gradient by active transport. Further detail of the action of carrier proteins was often included. However, many candidates did not realise that a low pH means that the contents of lysosomes are acidic and have a high concentration of hydrogen ions. Many candidates stated that hydrogen ions are moved out of lysosomes.

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Paper 9700/22
AS Level Structured Questions

Key messages

The rate of an enzyme-controlled reaction changes with changes in substrate concentration. Descriptions of curves, such as those in **Fig. 5.2** in **Question 5(c)**, should avoid using terms related to time to describe the steepness of a curve. For example, a number of responses described the steep gradient of the curve at the lower cellulose (substrate) concentrations as being 'a rapid increase' and the change to a less steep gradient as 'slowing down'.

In **Question 6**, it was not correct to describe the transmission of HIV as 'becoming infected with HIV/AIDS'. In a response, it should be clear that it is the virus that is transmitted from an infected to an uninfected person and that the effects of the virus cause the weakened immune system. 'HIV/AIDS' should be used to describe the condition of the person who has become ill with one or more infectious or non-infectious diseases as a result of a compromised (weakened) immune system.

Descriptions of globular proteins frequently include the terms 'hydrophilic' and 'hydrophobic'. In **Question 3(e)**, candidates could gain credit for explaining that the areas of the protein on the 'outside' of the molecule would consist of amino acids with hydrophilic R groups (or the reverse argument on the 'inside' for amino acids with hydrophobic R groups). Credit was not given for more vague descriptions such as 'the outside of the protein becomes hydrophilic'. A common error was to incorrectly use knowledge of triglycerides and phospholipids and state 'hydrophilic heads' for hydrophilic R-groups, and 'hydrophobic tails' for hydrophobic R groups.

General comments

Overall, candidates paid attention to the command or instructional terms used in the questions, and when a question had two of these, such as 'describe and explain' or 'suggest and explain', most addressed both parts. There were outstanding performances from some candidates. These were packed with relevant information, well organised and often showed a level of knowledge beyond syllabus requirements. Frequently, good responses contained concise sentences that addressed one or two main ideas that could easily be credited, and the number of sentences (or bullet-point style sentences) matched or exceeded the credit that could be attained. Other good overall performances included the wide use of appropriate, correctly spelled scientific terminology and completion of all items within the exam paper.

One of the characteristic features quoted as a difference between plant cells and animal cells was the presence of large permanent vacuoles in plant cells. Some candidates used this knowledge to incorrectly identify the cells seen in **Fig. 1.1** in **Question 1** as animal cells. Candidates should remember, when viewing meristematic tissue in prepared microscope slides or photomicrographs of root tips, that these plant cells have not differentiated and so will not contain large permanent vacuoles.

The instruction given in **Question 2(b)** made it clear to candidates to use ticks and crosses to complete **Table 2.1**. Many did not follow this instruction and only used ticks, leaving the other boxes blank. The aim of asking candidates to have completed every box within the table was to help them make sure that they had considered every cell (box).

The information given in an introduction to a whole question is sometimes useful to help formulate a response for one of the part questions that follows. **Question 3** was an example of this. The first sentence provided candidates with the knowledge that they could consider a steroid hormone to be lipid. This was useful to answer **Question 3(b)** to help candidates understand why the hormone would not pass through a transport protein.

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The importance of reading a question carefully was highlighted in **Question 4(a)**. Some candidates concentrated on stating the more general effects of tar on the gas exchange system rather than focusing on the cells lining the gas exchange system. Descriptions of the consequences of effects on cells were not required, such as writing about tumours for lung cancer or mucus accumulation narrowing the lumens of the airways when relating to chronic bronchitis.

Graphs appearing in questions showing the effect of substrate concentration on the rate of a particular enzyme-catalysed reaction may not always show a textbook plateau at the higher substrate concentrations as researchers may not have carried out experiments at higher concentrations. In **Fig. 5.2** of **Question 5(c)**, some candidates did not study the curve carefully and described the rate of reaction as levelling off or plateauing, which was not the case.

In **Question 6**, it was evident that some candidates equated the term 'disease' to 'infectious disease', with a number in **Question 6(a)** writing about myasthenia gravis as an infectious disease. Also, in **Question 6(c)**, some answered as if TB (tuberculosis) was the name of the causative bacterium, rather than the infectious disease caused by the bacterium.

Comments on specific questions

Question 1

(a) (i) Most were able to identify the correct stages of mitosis for cells **E** and **F**. Where only partial credit was gained, this was usually for correctly stating that **E** was in metaphase and incorrectly identifying **F** as being in telophase, rather than in anaphase. Here, candidates could have noticed the lack of any signs of a nuclear envelope re-forming around the daughter chromosomes to help guide them away from telophase.

(ii) Correct ideas regarding the spindle, attachment to the centromere and involvement in chromosome movement were seen in the responses. Candidates are not required to know the terms 'centrosome' and 'kinetochore'. Although many made correct reference to these, there were a number who confused 'centrosome' with 'centromere'.

(iii) The presence of cells with cell walls was the most common correct reason to identify **Fig. 1.1** as showing plant cells. Many gave a reasonable description of the uniform shape and organisation of the cells in the tissue. A small number of candidates noticed that there were no cleavage furrows visible, or that cell plates could be seen in some of the cells at the end of mitosis. Those who did not correctly identify that **Fig. 1.1** showed a region of plant tissue frequently explained that large vacuoles could not be seen, not realising that these are lacking in cells of meristematic tissue.

(b) Hydrogen bonds were well known as the bonds holding the two strands of DNA together. Fewer named ligase as the enzyme joining the fragments together, with many incorrectly naming helicase. Although many knew that the enzyme involved in chain elongation was a polymerase, it was important to qualify this further to state DNA polymerase. Candidates who did not gain credit for **D** either named the regions at the ends of chromosomes as centromeres rather than telomeres or could only vaguely recollect the correct term and gave a term that was not recognisable as 'telomeres'.

Question 2

(a) Well-constructed responses addressed both aspects mentioned in the question, so that it was clear whether an explanation was related to the decrease in sugar taken up or the increase in water as the young leaf matures. There were different ways to show an understanding that the developing leaf makes a transition from sink to source, and there were a number who expressed this very well. Many understood that photosynthesis would be occurring, which would decrease the demand for imported sugar. Some also understood that the maturing leaf would be growing to make valid statements. Weaker responses gave more disconnected statements, for example noting in one statement that the leaf would be photosynthesising and then in a later statement giving a different suggestion as to why less sugar is taken up. The most common correct answer for explaining the increase in need for water was that it is a reactant in photosynthesis. This explained only a minor proportion of the increase in quantity of water used. Fewer made the link between an increase in leaf size and increase in the number of stomata and rate of transpiration.

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(b) Many demonstrated sound knowledge of the structure of the three cell types involved in transport in plants. The structure of the companion cell was generally the best known. A number of responses incorrectly suggested that the phloem sieve tube element contained lignin and did not have a cell surface membrane.

Question 3

(a) (i) The strongest responses gave comparative sentences to describe the differences between blood arriving at the arterial end of the capillary network shown in **Fig. 3.1** and the tissue fluid. Candidates commonly cited differences in red blood cells, oxygen concentration and proteins. Fewer noted differences in carbon dioxide concentration. An accurate description of the difference in protein composition showed an understanding that, although some proteins can leave blood to enter tissue fluid, large proteins, commonly called plasma proteins, remained in blood and were not present in tissue fluid. Stating that no proteins were present in tissue fluid was not credited, as this would describe a situation where, for example, protein hormones and antibodies would not be able to leave blood to reach body cells. Most compared blood at the arterial end of the network with tissue fluid as required, but there were a number who did not read the question carefully and compared blood at the arterial end with blood at the venous end.

(ii) **Fig. 3.1** included some lymph capillaries in addition to the capillary network and related blood vessels. Many named lymph or lymphatic fluid as the fluid that drained into the vessels. Those naming plasma were not credited as this term should be reserved for the fluid within blood vessels.

(b) Hormone **S** was described in the introduction to **Question 3** as a steroid (lipid) hormone. Well-revised candidates could use knowledge of the non-polar, hydrophobic nature of lipids, the structure of the cell surface membrane, and different transport mechanisms to gain full credit in this question. Some made the incorrect assumption that a transport protein was needed only for active transport and suggested that if a molecule was moving down the concentration gradient, it did not need a protein. Other incorrect answers stated that the hormone was a polar molecule, and that these could not travel through a transport protein. A number described endocytosis, even though this was not indicated in **Fig. 3.2**.

(c) Most candidates gave a good explanation and some of the most accurate referred to the binding site of receptor **R**. There was evidence in the weakest responses that the information provided had not been fully understood – hormone **S** was referred to as a substrate and receptor **R** an enzyme molecule. Another error seen was to describe hormone **S** or receptor **R** as an antigen. It was not acceptable to state that the hormone and receptor had 'matching' shapes as this implies similar, and not complementary, shapes.

(d) (i) In **Fig. 3.2**, the hormone-receptor complex was shown passing into the nucleus through a channel in the nuclear envelope. Many realised that stating 'nuclear envelope' as the structure though which the complex enters would not gain them credit, as this was labelled in **Fig. 3.2**. Some candidates needed to take greater care to use the correct terminology, stating 'nucleus pore', rather than 'nuclear pore'. Descriptions such as 'hole in nucleus' or 'gap in nucleus' were not credited. Other incorrect responses included 'plasmodesmata', 'cell surface membrane' and 'phospholipid bilayer'.

(ii) DNA was labelled in **Fig. 3.2** and messenger RNA was shown in the key. With these, and the diagrammatic representation, many knew transcription and translation as the correct terms for the processes occurring at **B** and **C**. Where only partial credit was gained, this tended to be for using the correct names of the processes but getting them the wrong way round, or correctly naming one of the processes, and giving 'DNA replication' or 'protein synthesis' or even 'translocation' as the other process. Some did not read 'processes' in the question and attempted to name enzymes that might be involved, or for transcription to give a description of the DNA strand, such as 'template strand'.

(iii) Most were confident in naming structure **G** as a ribosome. The key for **Fig. 3.2** identified the messenger RNA molecule and the polypeptide and so gave candidates enough information to identify a correct cell structure. The weakest responses did not make good use of this key and suggested a cell structure such as 'vesicle' or 'vacuole' or 'Golgi body'. Some named a type of molecule, such as 'glycoprotein' or 'tRNA'.

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(e) Candidates who produced a fluent and concise account used the correct scientific terminology required and went through a logical sequence describing how each polypeptide with its primary structure could change and take on secondary and tertiary structures and interact with each other to produce the quaternary protein. Some noted other changes that could occur, with the most common of these being addition of other non-protein groups. Fewer noted that the first amino acid, methionine, could be removed. Some realised that the response could also include information about the structure of a globular protein and wrote about the location of the amino acids with hydrophilic and hydrophobic R groups.

Less precise responses showed knowledge of alpha-helices and beta-pleated sheets and of the interactions between R groups of amino acids and needed to relate this to a particular change that would occur to the polypeptides to result in a named level of protein structure. It was important to remember that the functioning protein referred to in the question was composed of three polypeptides and that it was a globular protein. This meant that descriptions of haemoglobin, which is globular but has four polypeptides, and descriptions of collagen, which has three polypeptides but is a fibrous protein, should not have been included. Both of these proteins also do not have identical polypeptides in their quaternary structure. Although there was no prompt to do so, a number decided to describe events that occur within the Golgi body. For this type of response, it was still possible to gain credit if the candidate provided enough detail about the changes that would occur to the polypeptides.

Question 4

(a) There were some very knowledgeable answers in response to this question, with many giving accounts that included good use of the correct scientific terminology. For example, in lung cancer, there were relevant statements related to tar using the term carcinogen and/or mutagen, with many being able to write about mutations in the correct context and outlining changes to protooncogenes and tumour suppressor genes. Some candidates wrote too generally about tumour formation, which was not relevant. For chronic bronchitis, the most common correct ideas given were the effects of tar on the cilia and the consequential loss of function and the increase in mucus production by enlarged goblet cells and/or mucous glands. Some could have improved their response by writing about cilia as the cell structures responsible for moving mucus, rather than more vague statements about the inability of ciliated cells to function. Many wrote about mucus accumulating, which was an effect on the lumen of the gas exchange system and not an effect on the actual cells. Some were confused with emphysema and stated points related to this and not to chronic bronchitis.

(b) Most candidates were able to gain full credit in this question. A small number gave cm^2 or m^3 for the volume, or made errors in completing the values for cube **C**. A quick check of the final column in **Table 4.1**, showing a SA:V of 2:1, should have alerted some candidates that a mistake had been made in their calculation of surface area and/or volume.

(c) This was usually correct. For those who did not gain the credit, the reverse order **C**, **B**, **A** was given.

(d) The ability to apply knowledge and understanding to an unfamiliar context of lung volume reduction surgery for people with emphysema was assessed. Good responses showed an understanding that the removed, diseased lung tissue had a proportionately far lower surface area to volume ratio than healthy lung tissue, which would result in the increase in total SA:V after surgery. These responses included details of how alveoli have been damaged in people with emphysema to produce the lower SA:V. A proportion of responses simply suggested that if lung tissue was removed, it meant that volume was reduced, so increasing the ratio. These did not take into account the surface area. Others wrote about changes that would occur in the person after surgery, such as an improvement in gas exchange, which was not required for this question.

(e) Careful consideration of the question posed led to many giving all the expected points. Weaker responses made a general comment about arteries transporting oxygenated blood and veins transporting deoxygenated blood, without consideration that the opposite occurs for the pulmonary artery and pulmonary vein. For those who wrote about deoxygenated and oxygenated blood in the heart, a proportion could have gained full credit if they had named the septum rather than just stated that the two types of blood were kept separate and also if they had stated the sides of the heart through which each type of blood passed.

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Question 5

(a) A visual cue in **Fig. 5.1** and a written description allowed the majority to identify structure **X**. Only a portion correctly used the singular term 'plasmodesma' rather than the plural 'plasmodesmata'. Some incorrect answers included 'sieve pore', 'lignin', 'stomata', 'cell wall' and 'cytoplasm'. Many knew that substances could pass from one cell to the adjacent cell through the plasmodesma and to gain the credit this needed to be qualified with a relevant example. Some noted that water passed through the plasmodesma but then gave a contradictory fact by describing this as 'osmosis'.

(b) (i) Many had taken note of the information provided in the introduction to **Question 5** and explained that because pectin is a polysaccharide it would not be synthesised at the ribosome, because this organelle is the site of protein synthesis. Those who had not realised that pectin is a carbohydrate gave incorrect explanations involving Golgi body functioning, such as suggesting that ribosomes only produced polypeptides and Golgi bodies modify these to produce functioning proteins.

(ii) Exocytosis was the only acceptable answer and the vast majority of candidates gained the credit available. Of the few candidates who did not, a range of incorrect answers was seen, including endocytosis, active transport, facilitated diffusion, symplast pathway and phloem.

(c) Confident candidates could cope well with this unfamiliar context involving cellulase acting on different concentrations of cellulose. After describing the results shown in **Fig. 5.2**, these candidates applied the principles learned to gain full credit. These responses avoided describing the changes in the curve as 'slowing down' and wrote about a less steep increase in the rate of the reaction at the higher substrate concentrations. The most observant noted that the rate was still increasing up to the highest cellulose concentration tested. Descriptions were frequently supported by correct values extracted from **Fig. 5.2**. Sometimes, the descriptions incorrectly involving time still managed to give a correct explanation in terms of enzyme-substrate collisions, availability of active sites and changes in the factors limiting the rate of reaction. However, some who wrote that the higher concentrations produced a slower rate explained this as the substrate running out. Details needed to be more precise in some explanations. For example, 'active sites', rather than 'cellulase', should have been described as being available or becoming saturated.

(d) (i) The reason for using ultrasound in the production of juices was briefly explained in the introduction to this question. Many made the error of interpreting contaminating microorganisms as being inhibitors of enzyme action. This meant that their focus was to suggest that removal of microorganisms meant that enzyme action was no longer inhibited, so improving K_m and V_{max}. It was still possible to gain some credit if candidates went on to suggest points that were correct and the most common idea seen was to suggest that the lower K_m for pectinase meant that ultrasound had increased the affinity for pectin. Fewer gave more detail than this. The higher V_{max} for xylanase was less well answered. Many wrote about enzyme-substrate collisions and some remembered to include the idea of a higher rate.

(ii) The majority realised that the final column in **Table 5.1** should be used to work out the correct answer. Some did not gain the credit because they chose to concentrate on the changes in V_{max} and so identified only cellulase and xylanase reactions benefitting from ultrasound.

Question 6

(a) Many gave two or more acceptable explanations to gain full credit. Some were careful to point out that the immune system failed to distinguish between self and non-self, continuing to give details of myasthenia gravis (MG). It was rarer to see a reference to the inability of the immune system to destroy the defective lymphocytes. Others gave more vague or incomplete statements that could not always be credited. For example, stating that the immune system cannot recognise self and non-self antigens does not have the same meaning as being able to recognise antigens but not being able to perceive the difference between self and non-self. Some noted that B-lymphocytes were involved and needed to explain that these resulted in the production of antibodies against the ACh receptor, or the self-antigen, rather than just stating that the cells attack the self-antigen. Weak responses showed a gap in knowledge and gave general statements about lymphocytes not being able to carry out their function. Some of these thought that MG was an infectious disease.

(b) There were some comprehensive, sequential accounts for this question. The best answers showed an understanding that antigens of defective B-lymphocytes and T-lymphocytes were the

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equivalent in this unfamiliar example of the non-self antigens normally contained within a vaccine. For those who gave a general account of how active immunity could be gained from a vaccine containing antigens of a pathogen, partial credit could still be gained. One common error in weaker responses was to state that the vaccine contained antibodies.

(c) Almost all candidates understood that a potential issue with preventive treatment against TB was the risk of developing antibiotic resistance. Those not gaining the credit incorrectly wrote about antibiotic resistance of the person with TB rather than of the bacterial pathogen or stated that TB would develop antibiotic resistance. Some were not credited because they did not write enough, for example 'may become resistant', while others used the term 'immune', which was not credited.

(d) The information provided in Fig. 6.1 aimed to provide stimulus material for discussion. Some candidates realised that the greatest problem was the large number of people who did not know that they had been infected, and skilfully used the data in Fig. 6.1 to gain full credit, writing about the impact caused by these people or pointing out the advantages gained by those who did know their status. Others appeared to miss this statistic and attempted to write about the information in Fig. 6.1. It was not always possible to give credit when this occurred as the answers tended to be very general statements about HIV and HIV/AIDS. Some were not clear in distinguishing between the virus, HIV and HIV/AIDS, as noted in Key messages.

(d) In this question, candidates were asked to discuss the importance of only 75% of people estimated to be living with HIV knowing that they were infected with the virus. The information provided in **Fig. 6.1** aimed to provide stimulus material for this discussion. Some candidates realised that the greatest problem was the large number of people who did not know that they had been infected, and skilfully used the data in **Fig. 6.1** to gain full credit, writing about the impact caused by these people or pointing out the advantages gained by those who did know their status. Others did not take this statistic into account and attempted to write about the information in **Fig. 6.1**, resulting in some very general statements about HIV and HIV/AIDS that could gain little or no credit. Some were not clear in distinguishing between the virus, HIV and HIV/AIDS.

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BIOLOGY

Paper 9700/23
AS Level Structured Questions

Key messages

The membrane that forms the outer boundary of the cell and contains the nucleus and cytoplasm should always be termed the 'cell surface membrane' to distinguish it from the cell membranes associated with organelles within the cell. Describing a vesicle moving to 'the membrane' in **Question 1(c)(ii)**, does not necessarily suggest movement to the surface of the cell for exocytosis to occur.

When describing the process of translation, such as in **Question 3(a)**, the anticodon of a tRNA molecule should be stated as being complementary to the codon of an mRNA molecule. Similarly, in enzyme questions such as **Question 3(c)(i)** and **(ii)**, the term complementary can be used to compare the shapes of the substrate or competitive inhibitor with the shape of the active site of the enzyme. The terms 'matches' and 'matching' can be used to imply similarity and so should be avoided when answering questions such as these.

Although large permanent vacuoles are a common feature of mature plant cells, candidates should be aware that the phloem sieve tube elements that make up phloem sieve tubes do not have these vacuoles as these would greatly hinder the flow of phloem sap within the tubes. Some candidates in **Question 4(b)**, knowing that the cytoplasm of the sieve tube element is peripheral, mistakenly thought that this was because of the presence of a vacuole.

General comments

Some candidates were able to cope well with the unfamiliar material presented in this examination and were skilful in bringing out the main biological principles and concepts required, while still referring to the context of the question. Knowledge of the syllabus content was evident and the extended responses were well thought out, contained concise informative statements, and used appropriate scientific terminology. All main syllabus topics were covered in this examination and, although some candidates displayed excellent knowledge and understanding of many syllabus topics, a higher standard could have been achieved by being better prepared in some areas, particularly in knowledge of the structure of phloem sieve tube elements and identification of blood cell types in blood smears.

Being able to use the correct terminology can allow concise creditworthy statements to be produced, which saves time when answering a question. This was notable throughout **Question 1**, which relied quite heavily on the use of terms associated with cell structures and the functions of organelles.

Fig. 2.1 in **Question 2(e)(i)** listed four reasons that needed to be discussed about the success of the smallpox global vaccination programme. Many formulated a response that only included four discussion sentences, one for each reason. This was not always a successful strategy when one of their ideas was invalid or too vague to gain credit. It is usually more beneficial to candidates in extended answers such as these to include a few more pertinent ideas and so increase the chance of achieving full credit.

The introduction to **Question 3** presented the enzyme known as HIV protease, which became the theme of the question. The second sentence of this introduction outlined that translation was the synthesis of a polypeptide chain. **Question 3(a)** that followed required an extended response describing translation. Many candidates were able to produce an excellent account that helped improve their overall performance. Some others had clearly not digested the information in the main introduction and gave an account that was a description of transcription, ending up with the formation of mRNA and not a polypeptide of HIV protease.

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The importance of reading a question carefully was highlighted in **Question 4(b)(i)**. **Fig. 4.1** was a diagram of two cell types of phloem, the sieve tube element and the companion cell. Some candidates misread the question and added many correct labels to the companion cell. The phloem sieve tube element, which needed completing and labels adding, was then left blank.

In **Question 5**, those candidates who had experience of viewing prepared microscope slides or photomicrographs of blood smears were more likely to be able to transfer their knowledge to name the four blood cell types drawn in **Fig. 5.1**.

For many candidates, **Question 6** proved to be their best-performing question. This was mainly based on Topic 5 of the syllabus but included a calculation to determine the magnification of **Fig. 6.1** from Topic 1 of the syllabus. Questions of this type in previous examinations have often required conversions to μm, whereas here a conversion to nm was needed. A number of candidates stumbled at this point by converting incorrectly from mm to nm, or more frequently, from cm to nm.

Comments on specific questions

Question 1

(a) The strongest responses displayed full knowledge of the structure and function of rough endoplasmic reticulum (RER) and smooth endoplasmic reticulum (SER). These gave comparative sentences so it was clear to see the differences between the two types of endoplasmic reticulum. Others were more knowledgeable of RER and frequently the function of SER was described incorrectly, such as energy storage, Golgi body functions and sorting molecules. Good answers described ribosomes as being on the outer surface of the RER rather than stating that 'RER contains ribosomes', which implied that they are located within the RER lumen. Few gave a structural difference other than the presence and absence of ribosomes.

(b) Knowledge that a phospholipid is composed of a phosphate and two fatty acids was widespread, with a smaller portion gaining full credit by correctly describing ester bonds or attachment of the phosphate and fatty acids to glycerol. In a question about structure of a phospholipid, it is not enough to simply state that a phospholipid is composed of 'a hydrophilic head and two hydrophobic tails'. Some omitted to state that there were two fatty acid tails in a phospholipid and many did not mention glycerol at all.

(c) (i) The Golgi body is the only cell organelle in a transmission electron micrograph to look like a stack of cisternae, and for some candidates this was all that was needed to gain full credit. For those who described flattened sacs but did not note the layered or stacked appearance, it was possible to give another identifying feature to gain credit. Some also drew a sketch, which if correct, helped to support their answer. Some attempted to describe flattened sacs as 'pancakes' or 'plates. Descriptions such as these implied solid structures rather than sacs. Weaker responses described shapes, such as semi-circles, or the reactions that would likely be occurring within the organelles. Some did not notice that the question instructed them to describe features other than the presence of Golgi vesicles and included information about these in their answer.

(ii) There were numerous clear, sequential descriptions for this question. Stronger answers began after packaging of the secretory proteins into the secretory vesicle, as instructed, while others wasted time by repeating information already provided. A few candidates gave correct details of movement through the cytoplasm involving the cytoskeleton. Good answers noted that movement was towards the cell surface membrane rather than just stating 'membrane', and many correctly described the process as exocytosis. Some of those that described the vesicles moving to the cell surface membrane did not give further detail of the vesicles fusing with the membrane. There were also some who suggested incorrectly that the secretory proteins exited the cell though transport proteins once the vesicles had reached the cell surface.

(iii) This was generally well answered. Many stated the role of glycolipids as receptors for cell signalling molecules. Stating that they were involved in cell signalling needed more detail. A proportion suggested a role in membrane permeability or confused glycolipids with glycoproteins and outlined transport across the membrane.

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Question 2

(a) The most common correct answer was the presence of the capsid or protein coat. Some chose to give an answer involving nucleic acid and here care was needed to show an understanding that only DNA or RNA was present. Some mistakenly suggested that all viruses only contain RNA. It was not possible to state an absent feature and gain credit. Many weaker responses cited a lack of a nucleus or gave a feature found in a prokaryote, such as a plasmid.

(b) A small proportion of candidates had learned and remembered the names of the viruses that cause smallpox and measles, and most of these were able to spell them correctly. The most common mistake was to spell 'Morbillivirus' with only one letter 'l'. A few wrote the names the wrong way round and a large number simply wrote 'smallpox virus' and 'measles virus' or used other viral diseases or viral names, such as 'flu', 'HIV', 'polio, and 'Rubella'.

(c) Strong responses avoided giving a description of antibiotics or penicillin and focused on explaining why they could not be used to treat measles. For example, stating that penicillin is used to treat bacterial diseases is a correct fact but does not explain why it cannot be used to treat a viral disease such as measles. Some needed to improve their response by explaining that the antibiotic only works on bacteria and not on viruses and then explain that viruses do not have the cell walls on which penicillin can act. Many gained credit for giving an explanation involving cell walls. Other ideas that could have gained credit were seen on rarer occasions. Some thought it was enough to state 'antibiotics would not work because measles is caused by a virus' and without further detail this did not get credit. Weak responses equated measles to the causative organism and just stated 'because measles is a virus'.

(d) This was often well answered, with many explaining that a person with HIV/AIDS had a weakened immune system and introducing the idea of opportunistic infections that could be caused by bacteria. Credit was given to those who understood that antibiotics were used for some HIV-related diseases and not for controlling HIV infection. Some erroneously thought that antibiotics were able to boost an immune system.

(e) (i) There were some very fluent accounts for this extended response and a high proportion of candidates gained full credit. Most responses maintained focus and only addressed the reasons listed in **Fig. 2.1**. Many used correct scientific terminology when giving detail about the immune response that would occur. There were many alternative discussion points related to the thermostable vaccine and the ease of administration of the vaccine and a wide range of valid statements were credited for these. Reference to the vaccine giving immunity to people was made in the introduction to the question, so that credit was only given when it was pointed out that immunity would be long lasting.

(ii) Most knew that the immunity gained from the smallpox vaccine was artificial immunity. However, a number incorrectly thought that this was an example of passive, rather than active, immunity.

Question 3

(a) This was an extended response that was most effectively organised as a step-by-step account. There were some answers that flowed sequentially and were very accurately described. Others began well and showed an understanding of the roles of mRNA and tRNA but were vague in explaining how it was possible for peptide bond formation to occur, mentioning only the action of a single tRNA molecule at the ribosome or describing tRNA detaching before peptide bond formation occurred. Some wrote about anticodons and needed to include tRNA in their answer, while others omitted to describe the binding of an mRNA codon to the anticodon of a tRNA molecule. There were quite a number who described transcription and continued to describe translation. These weaker responses were able to gain only very limited credit.

(b) The majority of candidates who gained full credit followed the instruction given by the command word to compare and gave three valid differences between the peptide bond and the tertiary structure bonds. A few compared the similarity that peptide and disulfide bonds are covalent bonds before considering differences. Details of the bonds between R groups was not as well-known as the peptide bond. It was quite common for candidates to think that the peptide bond was weaker than one or more of the tertiary structure bonds. Where no or only partial credit was given, this was often because many simply listed the different types of bonds used to form the tertiary

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structure of proteins, without identifying them as R group interactions, and making no attempt at comparison with peptide bonds.

(c) (i) This question used the enzyme HIV protease, which is important for the successful replication of HIV, to assess knowledge and understanding of the induced fit mechanism of enzyme action. There were many who applied themselves to give confident answers. These included sensible suggestions of the role of the flap region of HIV protease. Others needed to be more detailed, for example describing the enzyme binding to the polyprotein or the enzyme changing shape to fit the polyprotein without mentioning the active site of the enzyme. Some candidates thought that induced fit meant the substrate polyprotein changes shape to fit into the active site.

(ii) Some candidates realised that indinavir would inhibit enzyme action and so identified the type of inhibition occurring and gave good explanations at the molecular level. A number omitted this part and went ahead to explain that the necessary protein products would not be produced and so HIV replication would be hindered. This gave them only partial credit. Some responses showed an understanding that indinavir would bind to the active site and needed to go on to explain the effect of this. The weakest responses suggested that the drug would act as a pain killer or would relieve symptoms.

Question 4

(a) There were some clear definitions given for disaccharide and polysaccharide. Most knew what the prefixes 'di' and 'poly' meant. Some explained that disaccharides were composed of two sugars or two sugar molecules. This did not confirm the understanding that they were composed of monosaccharides. Some gave ambiguous examples, such as 'disaccharides are composed of two sugars such as lactose'. It was still possible in these cases to gain full credit if the correct type of bond was named and the definition of a polysaccharide was acceptable. Some candidates mistakenly described a polysaccharide as a sugar.

(b) (i) A cell structure needed to be drawn on the diagram of the phloem sieve tube element and a label added. Many remembered that the sieve plate with sieve pores was a characteristic feature of sieve tube elements and drew at least one sieve plate in a correct location. Some omitted to add a label. Less frequently candidates drew and labelled peripheral cytoplasm and at least one mitochondrion on **Fig. 4.1**. Some candidates labelled the mitochondrion as 'mitochondria'. There were many who added a nucleus and other cell structures, particularly a large vacuole, indicating a lack of correct knowledge of the structure of this cell type. **Question 4(b)(ii)** stated that the mass flow of phloem sap occurred in the sieve tube, which should have served as a reminder that phloem sieve tube elements function as components of a transport vessel and would not have large cell structures that would hinder flow.

(ii) In this question, candidates needed to recall the cause-and-effect sequence of events that occurs for mass flow of phloem sap from source to sink. Most who had learned this realised that they needed to describe the event that caused the change, but some did not do so. For example, for the first change, stating 'because sucrose is present which lowers water potential' was not enough to gain credit. Some explained what would happen after the change and so described the entry of water for the decrease in water potential or were too vague in their response, for example 'water movement' for the increase in hydrostatic pressure. Some gave answers related to the events occurring with hydrogen ions and companion cells or wrote about water transport and gave explanations involving transpiration or movement in xylem.

Question 5

(a) Identifying the red blood cell in **Fig. 5.1** was generally straightforward. The two different types of nuclei in the phagocytes helped candidates identify the neutrophil, with fewer correctly naming the monocyte. Macrophages are mostly found in tissue fluid, having matured from monocytes located in the blood. For this reason, prepared microscope slides that candidates will have viewed are unlikely to contain macrophages, which would have a more granular appearance. 'Phagocyte' for both the neutrophil and monocyte was accepted only once. Those who named the lymphocyte as B-lymphocyte or T-lymphocyte were credited, but at this level of detail it was not possible to tell the difference. Plasma cell was not acceptable as these have a quite different appearance to lymphocytes. A proportion thought that the lymphocyte was a monocyte. A variety of incorrect answers were seen. Sometimes these confused the relevant cell types expected or suggesting a platelet or white blood cell. Some labelled the red blood cell as haemoglobin. The very weakest

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responses included answers such as muscle cell, gamete and bacteria, or named cell structures such as the Golgi body and mitochondria.

(b) Most knew that the lower curve in **Fig. 5.2** would not be the curve representing blood pressure changes in the left ventricle, but there were a number that gave the value for the maximum pressure in the aorta as their answer. Fewer gave a correct time for the closure of the bicuspid valve. Some attempted to give one decimal place further than was reasonable when attempting to give the correct extracted value.

(c) (i) Responses gaining full credit explained how various effects caused by chronic obstructive pulmonary disease would allow chronic alveolar hypoxia to develop. Some gave good descriptions of symptoms of emphysema and chronic bronchitis and needed to complete their response by explaining how this would cause a situation where the partial pressure of oxygen in the gas exchange system would be lower. Others misinterpreted **Fig. 5.3** and/or misread the question and wrote about how a decrease in the lumen diameter of the pulmonary blood vessels or an increase in blood pressure could cause chronic alveolar hypoxia, which was the wrong way round and gained no credit.

(ii) Although most showed an understanding of the problems caused by a loss of alveolar capillaries, the responses gaining full credit were those paying attention to detail. The direction of movement of the respiratory gases needed to be stated when explaining that gas exchange would be impaired. Some wrote about oxygen and could have improved their response by including carbon dioxide. Fewer made reference to an increase in breathing rate. Some answers were too vague to gain credit, such as explaining that there would be difficulty breathing or that the lungs would not function well, or that the person would not have enough oxygen or too much carbon dioxide.

Question 6

(a) This calculation was generally well done. Many who lost out on some credit measured **A**–**B** in centimetres and then made a mistake when converting to nanometres.

(b) There were some very good attempts at this question, with many gaining full credit. Some diagrams were well drawn but did not have labels. The sister chromatids were usually labelled and many knew that the area with the constriction was the location of the centromere. This was sometimes mistakenly labelled as the centrosome.

(c) The strongest candidates realised that by the start of metaphase the chromosomes were fully condensed so would be most visible, and that by being in one plane in metaphase all the chromosomes would be in focus. There were many ways of indicating one or both ideas. It was expected that candidates should use the correct terms, such as describing the chromosomes all being orientated at the spindle equator or metaphase plate, so references such as ‘in the middle’ or ‘down the centre’ of the cell were not credited.

(d) Most knew that anaphase followed metaphase. The most common incorrect response was telophase.

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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 sources of error in a particular investigation as any variable that may change during the recording of results may make the results less accurate. They should also be able to suggest improvements to the procedure so that the effects of the errors identified are reduced.

Candidates should be aware that the wording of questions often indicates how the candidate should respond. The word 'explanation' may imply reasoning or some reference to theory, depending on the context. **Question 1(b)(ii)** stated 'suggest an explanation for the results between 0.2% and 6.0% hydrogen peroxide'. The candidate needed to give reasons as to why something happens, such as referring to the formation of more enzyme-substrate complexes between 0.2% and 3.0% and the active site of the enzyme being saturated between 3.0% and 6.0%.

General comments

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

It is helpful if candidates take the time to read the whole of each question before attempting it so that they are more able to plan their time carefully and answer the specific questions accurately.

Comments on specific questions

Question 1

(a) (i) The majority of candidates correctly measured the diameter and calculated the radius.

(ii) Most candidates correctly stated another variable that should be standardised.

(iii) The majority of candidates correctly transferred the value for the radius from **Question 1(a)(i)** and used it to calculate the total surface area of each height and number of potato cylinders. Most candidates correctly calculated the total surface area. The most common mistake was not showing how the total surface area was calculated from the surface area.

(iv) The majority of candidates organised their results clearly by presenting a ruled table and including a suitable heading for the independent variable and the heading for number of drops in 1 minute. The stronger candidates included the heading for the independent variable as total surface area and mm^2. The majority of candidates gained credit for recording the number of drops for all the surface areas of potato. Most candidates recorded results which showed that the number of drops for the smaller surface area was less than the number of drops for the largest surface area.

(v) Some candidates correctly stated surface area as the independent variable.

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(vi) Some candidates correctly suggested a suitable control. The most common error was to suggest a control variable such as the concentration of hydrogen peroxide.

(vii) Many candidates correctly stated that one source of error was the varying drop size released from the syringe and suggested measuring the total volume of hydrogen peroxide released instead.

Many candidates suggested that the syringe should be fixed in a clamp stand so that extra drops were not produced due to shaking of the syringe whilst holding it, which would lead to an error in the number of drops counted. Some candidates stated that the number of drops for each surface area was only counted once and suggested that an improvement would be to repeat the procedure several times and calculate a mean.

(viii) Many candidates correctly described how to modify the procedure to investigate the effect of changing temperature on the activity of catalase in the potato tissue. Some candidates correctly suggested using five different temperatures maintained by a thermostatically controlled water-bath. Some candidates correctly suggested keeping the surface area of the potato pieces constant.

(b) (i) The majority of candidates drew the graph, using the headings percentage concentration of hydrogen peroxide on the *x*-axis and distance moved in 1 minute / mm on the *y*-axis. The stronger candidates used scales of 1.0 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 sharp, clear ruled line accurately connecting the points.

The most common errors were labelling the incorrect axis, using a non-linear scale for the *x*-axis and extrapolating the line to 0.

(ii) Some candidates correctly explained that as the concentration of hydrogen peroxide increased there were more successful collisions between the substrate and enzyme molecules and more enzyme-substrate complexes were formed. Some candidates correctly explained that between 3.0% and 6.0% hydrogen peroxide all of the active sites were saturated so the distance moved remained constant.

A common mistake was to describe what the graph was showing rather than to explain why something was happening.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells or shading and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the whole leaf section. The stronger candidates gained credit for drawing at least four layers of tissue and showing the correct proportion of the vascular bundle in relation to the diameter of the leaf. Most candidates showed the detail of the sunken stomata. Many 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. Most candidates were able to draw four adjacent cells from the ring of cells surrounding the vascular bundle, with each cell touching at least one of the other cells and with double lines representing the cell walls. The most common errors were drawing a group of cells and drawing 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 identified at least one observable difference between the leaf section in **Fig. 2.1** and the leaf section on **J1**. Many candidates stated that the leaf in **Fig. 2.1** had hairs while the leaf on **J1** did not. Some candidates stated that there were more vascular bundles in **Fig. 2.1** than in **J1**. The stronger candidates stated that there was a ring of cells surrounding the vascular bundle in **J1** but that this was absent in **Fig. 2.1**.

(ii) Some candidates correctly suggested that the hairs or the rolled shape of the leaf trapped a layer of moist air which decreased the diffusion gradient. The most common error was not explaining how the layer of moist air prevented water loss.

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(c) (i) Many candidates correctly described counting squares that were covered by half or more than half of the palisade layer of the leaf section, as 1 cm^2. The most common error was to describe the addition of squares covered by less than half to make 1 cm^2.

(ii) Many candidates correctly counted and recorded the area of the palisade layer and the total area of the leaf section.

(iii) The majority of candidates were given credit for correctly showing the division of the area of the palisade layer by the total area of the leaf section.

(iii) The majority of candidates were given credit for correctly showing the division of the area of the palisade layer by the total area of the leaf section and multiplication by 100.

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Paper 9700/32
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 wording of questions often indicates how the candidate should respond. The word 'explain' may imply reasoning or some reference to theory, depending on the context. It is another way of asking candidates to 'give reasons for'. In **Question 1(a)(iv)**, where the question stated 'explain how tea can act as a competitive inhibitor of amylase' the candidate needed to give reasons as to how and why something happens, such as referring to the similar shape of tea to the substrate which means it is complementary to the active site of amylase, so tea competes with starch by inhibiting the binding of starch at the active site.

General comments

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

It is helpful if candidates take the time to read the whole of each question before attempting it so that they are more able to plan their time carefully and answer the specific questions accurately.

Comments on specific questions

Question 1

(a) (i) The majority of candidates completed **Fig. 1.1** to show how to carry out a serial dilution of 100% tea extract, showing the correct concentration below each beaker (50.0%, 25.0%, 12.5% and 6.25%) and transferring 5 cm^3 of the previous concentration to the next beaker and adding 5 cm^3 of distilled water to each beaker. The most common error was omitting to show the first transfer of 5 cm^3 from the first beaker to the second beaker.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for percentage concentration of tea (**T**) and the heading for time and minutes. The majority of candidates gained credit for recording the times for all the concentrations of tea extract. Many candidates correctly recorded results which showed that the time for the higher concentration of tea was longer than the time for the lower concentration of tea. The stronger candidates recorded the times as whole minutes.

The most common error was to record the colours observed at the different sampling times.

(iii) The majority of candidates correctly described the trend by stating that as the concentration of tea decreased the time taken to reach the end-point decreased.

(iv) Many candidates correctly explained that tea had a similar shape to starch and that this led to fewer enzyme-substrate complexes being formed. The stronger candidates stated that as tea had a similar shape to starch it was complementary to the active site of amylase and competed with starch at the active site.

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(v) Some candidates gained credit for suggesting the use of a syringe as an improvement to standardise the volume of the drops of iodine.

(vi) Most candidates correctly stated that one source of error was the unequal mixing of the solutions and some candidates suggested as an improvement a method for mixing the solution and that this should be carried out for a set period of time. Many candidates stated as an error that the starch was not in each concentration for the same length of time and that the improvement was to time each concentration separately. Some candidates correctly stated that another source of error was that starch was not at the same temperature as the concentrations of tea (**T**) and the enzyme (**E**) and that an improvement was to equilibrate the starch solution at the same temperature as the concentrations of tea and the enzyme.

(b) (i) The majority of candidates correctly calculated the concentration of caffeine / mg cm^{-3}.

(ii) The majority of candidates correctly used the headings given in the table to label the *x*-axis (type of drink) and the *y*-axis (concentration of caffeine / mg cm^{-3}). The majority of candidates also labelled each bar clearly and drew bars of equal width on the *x*-axis. The stronger candidates used a scale of 0.4 mg cm^{-3} to 2 cm for the *y*-axis and plotted each bar accurately. Most candidates drew ruled lines for the bars so that the vertical lines joined with the horizontal lines precisely. The most common error was using an incorrect scale for the *y*-axis so that the bars could not be plotted to the correct degree of accuracy.

(c) The majority of candidates correctly stated Benedict's reagent as the reagent used to determine the concentration of reducing sugar in the energy drink.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells or shading and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the correct sector of the stem that included two large vascular bundles. Many candidates gained credit for drawing at least three layers of tissue and showing the correct proportion of the vascular tissue in relation to the depth of the stem. The more able candidates showed that the vascular bundles were joined together. 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 epidermal cells, with each cell touching at least one of the other cells and with double lines representing the cell walls. The most common errors were to draw rectangular cells with lines that did not meet up precisely and groups of cells. Most candidates used a label line to show the cell wall of one cell.

(b) (i) The majority of candidates accurately measured the length of the scale bar with the appropriate units. Most candidates then showed the multiplication of the length of the scale bar to obtain the same units as the actual length of the scale bar (μm). The stronger candidates then showed the division of the length of the scale bar by the actual length of the scale bar (2400 μm). The most common error was the omission of units when showing the measurement of the length of the scale bar.

(ii) The majority of candidates listed at least two differences between **K1** and **Fig. 2.2** using only observable differences. Most candidates stated that there were more vascular bundles in **K1** and fewer in **Fig. 2.2** and that **K1** did not have extensions whereas extensions were present in **Fig. 2.2**. Some candidates stated that **K1** was circular in shape while **Fig. 2.2** was angular.

(ii) The majority of candidates listed at least two differences between **K1** and **Fig. 2.2** using only observable differences. Most candidates stated that there were more vascular bundles in **K1** and fewer in **Fig. 2.2** and that **K1** did not have extensions whereas extensions were present in **Fig. 2.2**. Some candidates stated that **K1** was circular in shape while **Fig. 2.2** was angular.

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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 encouraged to learn the methods for the tests for biological molecules as specified in the syllabus, especially the Benedict's test. The volume of Benedict's solution must be the same or more than the volume of the sample being tested and the temperature of the water-bath must be maintained at 80 °C or up to 100 °C. As this test was being used to compare concentrations of reducing sugar in **S1**, **S2**, **S3** and **S4**, the same temperature needed to be maintained for all the tests.

Candidates should be given the opportunity to draw both line graphs and charts. In this case, a chart was required. The bars should be plotted accurately and drawn exactly along the horizontal lines with a fine ruled line. All the lines, both vertical and horizontal should be sharp and unbroken.

General comments

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

It is helpful if candidates take the time to read the whole of each question before attempting it so that they are more able to plan their time carefully and answer the specific questions accurately.

Comments on specific questions

Section A

Question 1

(a) (i) Many candidates gained credit for stating that the reagent used to test reducing sugar was Benedict's solution and that the colours produced if a reducing sugar was present were either red, brown, green or yellow. The stronger candidates described that an equal or greater volume of Benedict's solution was added to the sample and then the mixture was heated to a temperature of 80 °C or more.

(ii) Many candidates gained credit for stating that the reagent used to test for starch was iodine solution and that the colour produced if starch was present was blue-black.

(iii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included an appropriately detailed heading for the independent variable (sample) and the dependent variable (colour or observation). The higher-performing candidates gained credit for recording four colours for the protein test, only three colours for the reducing sugar test and only two colours for the starch test. The majority of candidates recorded colours for all the tests carried out.

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(iv) Most candidates correctly identified the biological molecules present in **S1** as none, **S2** as reducing sugar, **S3** as protein and **S4** as starch.

(v) The majority of candidates correctly recorded the colours observed for **U** when carrying out the protein test as violet, the reducing sugar test as blue and the starch test as blue-black.

(vi) Most candidates correctly identified the biological molecules present in **U** as protein and starch.

(b) (i) Some candidates correctly stated that to test for lipid, ethanol should be added to the unknown solution, the test-tube shaken to mix the liquids and then the liquids poured into a test-tube of water. The stronger responses correctly stated that if a lipid was present a milky emulsion would be observed.

(ii) Some candidates correctly stated that no conclusion was possible as the observed positive result for the presence of non-reducing sugar could be due to the presence of reducing sugar.

(iii) Some candidates correctly described that by mixing solution **Z** with starch, allowing some time for the reaction to occur and then testing for the presence of starch by adding a sample of the mixture to iodine solution, they would determine whether the protein in solution **Z** was the enzyme amylase.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the whole section of the leaf. Many candidates gained credit for drawing at least three layers of tissue and showing the correct proportion of the vascular tissue in relation to the width of the leaf. Some candidates used a label line and label to correctly identify the palisade layer.

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

(b) (i) Many candidates correctly identified a xerophytic feature visible on **L1**. Stronger candidates were also able to state a different feature visible in **Fig. 2.1**.

(ii) Some candidates identified an observable difference between the vascular tissue on **L1** and in **Fig. 2.1** as the vascular tissue in **L1** was central while the vascular tissue in **Fig. 2.1** was situated in the mid-rib and in a line along the lamina.

(c) (i) Most candidates correctly used the headings given in the table to label the *x*-axis (type of tree) and the *y*-axis (percentage of total trees in the forest). Some candidates, however, labelled the incorrect axis or gave incomplete headings. Most drew bars of equal width and distance apart on the *x*-axis, used a scale of 10 to 2 cm for the *y*-axis and plotted each bar accurately. Stronger candidates completed their graphs by drawing ruled lines for the bars so that the vertical lines joined with the horizontal lines precisely.

(ii) Some candidates correctly calculated the total number of *Juniperus* trees in the forest by adding 10.5 (*Juniperus excelsa*) and 3.0 (*Juniperus drupacea*), showing division by 100, multiplication by 2344 and stating the total number of *Juniperus* trees as a whole number. The most common error was not using the percentage of total trees of *Juniperus excelsa* and *Juniperus drupacea*.

(ii) Some candidates correctly calculated the total number of *Juniperus* trees in the forest by adding 10.5% (*Juniperus excelsa*) and 3.0% (*Juniperus drupacea*), showing division by 100, multiplication by 2344 and stating the total number of *Juniperus* trees as a whole number. The most common error was not using the percentage of total trees of *Juniperus excelsa* and *Juniperus drupacea*.

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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 wording of questions often indicates how the candidate should respond. The word 'explain' may imply reasoning or some reference to theory, depending on the context. It is another way of asking candidates to 'give reasons for'. In **Question 1(b)(iii)**, where the question asked for an explanation for the difference in concentration of hydrogen peroxide remaining at 38.5 °C and at 58.5 °C, the candidate needed to make sure that they gave answers as to why something happens, such as referring to more hydrogen peroxide remaining at 58.5 °C, as fewer enzyme-substrate complexes are forming and the enzyme is becoming denatured.

General comments

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

It is helpful if candidates take the time to read the whole of each question before attempting it so that they are more able to plan their time carefully and answer the specific questions accurately.

Comments on specific questions

Section A

Question 1

(a) (i) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading pH and the heading for time with units 's'. The majority of candidates gained credit for recording the times for each pH. Many recorded results which showed the correct trend. The stronger candidates recorded the times in whole seconds.

(ii) Most candidates correctly stated that the dependent variable was the time taken to reach the mark at 15 cm.

(iii) Some candidates correctly stated that an appropriate control was to replace the yeast with an equivalent volume of water or use boiled yeast.

(iv) Most candidates correctly stated a time with appropriate units for **U** and estimated the pH correctly.

(v) Many candidates correctly stated that one significant source of error when carrying out step 4 to step 17 was that the liquids in the syringe were not mixed and an improvement to the method that would reduce the effect of this error was to move the syringe back and forth to help mix the contents.

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(vi) Many candidates correctly described how to modify the procedure by preparing at least five concentrations of hydrogen peroxide by serial or proportional dilution and keeping the pH at a constant value.

(b) (i) Most candidates correctly used the headings given in the table to label the *x*-axis (temperature / °C) and the *y*-axis (volume of potassium manganate(VII) used / cm^3). Some candidates, however, labelled the incorrect axis or gave incomplete headings. The more able candidates, for the *x*-axis, used a scale of 10 to 2 cm and for the *y*-axis, used a scale of 2 to 2 cm. Many candidates plotted all the points accurately and joined the points with a thin line. The most common errors were not using the correct scale and drawing lines which were too thick.

(ii) Many candidates used their graph correctly to state the volume of potassium manganate(VII) needed when the temperature was 45 °C.

(iii) The majority of candidates stated that at 58.5 °C there was more hydrogen peroxide remaining due to the enzyme becoming denatured and the formation of fewer enzyme-substrate complexes.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the whole root on **M1**. Many candidates gained credit for drawing at least two layers of tissue, showing the correct proportion of the vascular tissue to the diameter of the root, vascular tissue enclosed by the endodermis and a layer of cells beneath the epidermis. Most candidates used a label line and label to correctly identify the cortex.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin lines which joined up precisely and used most of the space provided. Many candidates were able to draw one large xylem vessel element and three adjacent smaller cells from the central tissue with each smaller cell touching the larger xylem vessel element and at least one of the other smaller cells, with double lines representing the walls. The most common error was to draw lines that did not meet up precisely or were too thick. Many candidates were credited for showing cells which had straight sides. Most candidates used a label line and label to show the cell wall of one cell.

(b) (i) Many candidates correctly identified a similarity between the section on **M1** and the section shown in **Fig. 2.1**, stating they were both circular in shape or had an epidermis, cortex and vascular tissue etc.

(ii) Many candidates listed at least three observable differences such as the position of the vascular tissue on **M1** was central while it was closer to the epidermis in **Fig. 2.1**, there were trichomes present on **M1** and trichomes were absent in **Fig. 2.1**, there was an endodermis present on **M1** and no endodermis in **Fig. 2.1**.

(c) (i) Many candidates showed division of 0.8 mm by 40 and multiplied the answer by 1000 to convert to micrometres.

(ii) Many candidates used the eyepiece graticule placed across the stem and found that the diameter of the section was 83 eyepiece graticule units and showed multiplication by the answer from **(c) (i)**.

(ii) Many candidates used the eyepiece graticule placed across the stem and found that the diameter of the section was 83 eyepiece graticule units and showed multiplication by the answer from **Question 2(c)(i)**.

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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 skills that can be applied to the requirements of the examination.

Candidates should be given the opportunity to draw both line graphs and charts. In this case, a bar chart was required. The bars should be plotted accurately and drawn exactly along the horizontal lines with a fine ruled line. All the lines, both vertical and horizontal should be sharp and unbroken.

General comments

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

It is helpful if candidates take the time to read the whole of each question before attempting it so that they are more able to plan their time carefully and answer the specific questions accurately.

Comments on specific questions

Section A

Question 1

(a) (i) Many candidates gained credit for assessing the state of risk as medium or high and stating the reason as the possibility of hot water burning the skin.

(ii) The majority of candidates organised their results for **U1**, **U2** and **U3** by presenting a ruled table. The stronger candidates included an appropriately detailed heading for the independent variable (reducing sugar solution) and the dependent variable (time / s). The more able candidates also gained credit for recording times as whole seconds. The majority recorded the time for **U2** as the shortest time.

(iii) Most candidates correctly identified the sample with the highest concentration according to the times recorded in their table.

(iv) Many candidates were able to complete **Fig. 1.1** to show how to carry out a serial dilution, showing the correct concentration below each beaker (1.00, 0.5, 0.25 and 0.125%) and transferring 10 cm^3 of the previous concentration to the next beaker and adding 10 cm^3 of distilled water to each beaker.

(v) The majority of candidates organised their results by presenting a ruled table. The stronger candidates included an appropriately detailed heading for the independent variable (percentage concentration of reducing sugar) and the dependent variable (colour or observation). The stronger candidates gained credit for recording colours for all the concentrations of reducing sugar and using the colours stated. The majority of candidates recorded the expected pattern of results.

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(vi) The majority of candidates stated the colour observed in step 25 and correctly estimated the concentration of reducing sugars in the sample.

(vii) Some candidates correctly stated that the procedure could be modified by the addition of acid to the sample, heating the mixture and subsequent addition of sodium hydrogencarbonate to neutralise the solution before carrying out the reducing sugar test.

(b) Most candidates correctly used the headings given in the table to label the *x*-axis (stage of ripening) and the *y*-axis (percentage concentration of reducing sugar). The more thorough candidates also added the labels, 'unripe', 'ripening' and 'ripe' as well as identifying which bars were glucose and which bars were fructose. Some candidates, however, labelled the incorrect axis or gave incomplete headings. Most candidates drew bars of equal width, grouped the bars in pairs or in groups of three and plotted each bar accurately. Most candidates used a scale of 5 to 2 cm on the *x*-axis. The stronger candidates drew ruled lines for the bars so that the vertical lines joined with the horizontal lines precisely.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing a quarter of the stem. Many candidates gained credit for drawing at least two layers of tissue and showing subdivision of the vascular tissue. Some candidates used a label line and label to correctly identify the xylem tissue.

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

(b) (i) Some candidates correctly showed the length of the scale bar in millimetres, multiplied by 1000 to convert to micrometres and then divided by 240 μm to calculate the magnification. The stronger candidates measured the length of the vascular bundle in millimetres and divided it by the figure for the magnification. The most common error was to measure the length of **X**–**Y** rather than the length of the vascular bundle.

(ii) Many candidates correctly identified the organ as a stem and gave the reason that the vascular bundles were in a ring near to the outside.

(iii) Many candidates identified only observable features and recorded at least three differences, such as stating that the overall shape of **N1** was square while the shape of the stem in **Fig. 2.2** was circular, that there were fewer vascular bundles on **N1** while in **Fig. 2.2** there were more vascular bundles, and that **N1** had bulges in the corners while in **Fig. 2.2** there were no bulges.

(iii) Many candidates identified only observable features and recorded at least three differences such as the overall shape of **N1** was square while the shape of the stem in **Fig. 2.2** was circular, that there were fewer vascular bundles on **N1** while in **Fig. 2.2** there were more vascular bundles, that **N1** had bulges in the corners while in **Fig. 2.2** there were no bulges.

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Paper 9700/41

A Level Structured Questions

Key messages

Candidates need to discriminate between different question command words. In particular 'describe' and 'explain' require different responses. Some candidates described the pattern of results on **Fig. 1.2** in their answer to **Question 1(b)(i)** but did not offer an explanation. Conversely, some candidates explained reasons for the results seen in **Fig. 6.1** for **Question 6(c)(i)** where the question asked them to describe the results.

Candidates also need to be prepared for situations where an answer needs to be comparative, for example explaining the increases and decreases in parameters due to an intervention such as chemical X in **Question 2(b)**, suggesting the benefits of genetic modification compared to non-GM crops in **Question 4(b)(i)**, and in describing transmission speeds of neurones in **Question 5(a)(i)**.

General comments

Most candidates were well-prepared and showed good subject knowledge across all syllabus areas.

Candidates were particularly secure in their knowledge in answers to **Question 1(a)** chloroplast pigments, **Question 3(a)(ii)** classification, **Question 4(a)** enzymes in genetic engineering, **Question 5(a)(i)** speed of impulse conduction, **Question 6(d)** negative feedback and **Question 7**, genetics. Candidates performed equally well on **Question 9** and **Question 10**. Questions which resulted in weaker responses included **Question 2(b)**, **Question 3(a)(iii)** and **Question 5(a)(ii)**, all of which involved developing or suggesting a reasoned explanation by applying knowledge within a novel context.

Comments on specific questions

Section A

Question 1

(a) (i) Candidates generally knew the role of photosynthetic pigments in absorbing light energy to excite electrons or for photophosphorylation. Some responses described energy transfer between pigments incompletely, stating that energy passes to the reaction centre but without naming the accessory pigments.

(ii) Most responses correctly located the pigments in the thylakoid membrane.

(iii) Most candidates correctly stated that the practical technique for separating pigments is chromatography.

(b) (i) The command word here was 'explain', so a simple description of the pattern of results on the graph did not receive any credit. Correct explanations linked different limiting factors to the increasing and plateau parts of the curve. The different areas of the curve were identified with coordinates with units read from the graph axes.

(ii) Correct responses referred to respiration occurring and using oxygen, while no photosynthesis was occurring as no carbon dioxide was available. It was a misunderstanding to suggest that when a plant cannot photosynthesise it respires instead, as plants respire at all times. Candidates who

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incorrectly viewed the *x*-axis of **Fig. 1.2** as showing time and referred to the plant as being in the dark at the start were making a common error.

(iii) Although most candidates realised that temperature affects the rate of photosynthesis, few specified how. Candidates needed to clarify the differing effects of high and low temperatures on the rate of an enzyme-catalysed reaction. Many successfully explained the idea of maintaining a constant temperature so that carbon dioxide was the only variable. Other explanations lacked clarity. Vague references to improving the accuracy or reliability of the results did not score.

Question 2

This question explored uses and generation of ATP. The effects of chemical X were described in the question stem in a comparative way, with various factors described as having increased or decreased or being in excess (implying a comparison with the normal or previous situation, without X). Answers needed to match this comparative idea and to use words like less, smaller, fewer or more, faster, increased.

(a) (i) Some answers described uses of ATP that were not reactions, for example muscle contraction, while others described catabolic (breaking down) reactions such as glycolysis. Clear examples of anabolic reactions that were given frequently included transcription (building up a polynucleotide), translation (joining amino acids to make a polypeptide) and glycogenesis (joining glucose residues to make a polysaccharide).

(ii) Candidates mostly stated that ATP is used to phosphorylate glucose. Many went on to state that this decreased the stability of glucose. Thorough responses were clear about the second phosphorylation step in which fructose phosphate is converted to fructose bisphosphate. A few candidates described the role of phosphorylation of glucose to prevent it from leaving the cell, and to maintain the diffusion gradient for glucose to enter the cell.

(b) (i) This was a challenging question, requiring a clear understanding of the electron transport chain and chemiosmosis to be applied within the novel scenario of the effects of chemical X. Few candidates linked the question information about protons leaking over the inner mitochondrial membrane to a decrease in the proton gradient resulting in fewer protons flowing through ATP synthase. Candidates needed to be able to carefully consider whether 'fewer/not as many' or 'none/no' are the correct responses to questions where something has changed. In this case no or none was inappropriate. Candidates often repeated the question information about more lipid metabolism without linking this to the idea of the people who experienced chemical X losing weight, showing that the lipids came from the body's own fat stores.

(ii) Candidates often made reference to glycolysis and anaerobic respiration without fully explaining that to produce more pyruvate and lactate, the rate of each process had to increase. Some candidates showed they understood that oxygen was being used faster at the end of the electron transport chain resulting in a shortage of intracellular oxygen.

(iii) Candidates rarely related excess heat release to the direct effect of chemical X. The effect was to decrease ATP synthase's role in harnessing the energy released as electrons moved down the electron transport chain. A proportion of this energy is normally released as heat as energy transduction is not completely efficient. With chemical X this increased.

Question 3

(a) (i) Well-prepared candidates answered effectively, with the most common answers being morphological, physiological and behavioural similarities. Some candidates mentioned that members of a species have a similar ecological niche, share a recent ancestor or can interbreed to form fertile offspring.

(ii) Most candidates successfully placed insects within the kingdom Animalia and domain Eukaryota.

(iii) Responses to this question tended to explain what a phylogenetic tree diagram would show without linking the depiction of evolutionary relationships to the task of classifying the species into genera, families and orders, so they did not fully answer the question. Some candidates grasped the basic idea by explaining that organisms with shared ancestry should be classified together.

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(b) (i) The question clearly stated that both the nucleotide and amino acid sequences should be considered so candidates needed to multiply (1478 × 103) by 2. Many candidates gave their final answer as 152 234 instead of 304 468 as they did not perform the last step in the calculation.

(ii) Candidates were knowledgeable about the advantages of bioinformatics for storing large quantities of data and rapid processing and analysis. The strongest candidates related these general principles to this question context. Weaker candidates referred to comparing sequences to a pre-existing public database, whereas the software for this project was custom built to compare the large number of sequences generated by the project itself.

Question 4

(a) Candidates generally listed three or four relevant enzymes but some gave information not relevant to the question context by referring to the actions of the enzymes in the genetic engineering process, not in the natural processes specified in the question.

The wording 'reverse transcriptase converts RNA to DNA' was misleading and candidates needed to be more precise about RNA being used as a template for the synthesis of a new strand of DNA.

(b)(i) Many benefits of GM crops compared to non-GM crops were best described in a comparative format, i.e. greater yield, higher profit, the use of less pesticide.

(ii) Some candidates answered this question as if they were continuing their answer to **Question 4(b)(i)**, listing more general benefits of GM crops. Strong responses used the information provided to craft an argument in support of Europe growing more GM crops.

(iii) Stronger candidates realised that either the area of non-GM crops or the total area available for growing crops was needed to calculate the percentage or fraction of crops that were GM.

Question 5

Candidates needed to apply their knowledge of nerve impulses and synapses to interpret the data and information provided in the question.

(a) (i) Candidates generally described the patterns shown in the bar chart and linked faster impulse conduction to myelination, saltatory conduction and wider axon diameter. Some weaker responses needed to make comparative statements or to consider all the data and information provided.

(ii) The strongest candidates successfully linked rubbing reducing the perception of pain to the faster speed in the $\mathbf{A^{\beta}}$ neurones compared to the neurones from the pain receptors.

(b) (i) Most candidates realised that endorphins would bind to their receptors on the presynaptic knob, though errors included stating that they bound to the acetylcholine receptors on the post-synaptic membrane, or stating that vesicles of endorphin were released and that these vesicles bound to the receptors. Candidates who had followed the logic of the TENS machine reducing pain explained that the endorphins stopped or decreased the usual sequence of steps of synaptic transmission. Some candidates did not realise that the TENS machine stopped pain impulses and they described all the steps of a normal impulse occurring. Weak answers included errors like suggesting the endorphins would travel along the post-synaptic neurone to the brain.

(ii) Most candidates suggested a disadvantage of using pharmaceutical drugs, such as side effects or slower action.

Question 6

Candidates generally showed a knowledge of the principle of negative feedback in thermoregulation in **Question 6(d)**. Not all could apply their knowledge to specific contexts and the line graph comparing the response to temperature change of two animal species in **Fig. 6.3**.

(a) There was a notable difference in the quality of answers between candidates who had learned how to describe thermoregulation using the correct terms and those whose answers were vague and lacking in scientific reasoning.

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Most candidates scored some credit, with an explanation of hairs rising on line three being the most common correct answer. Some mistakenly wrote that hairs trap 'hair' rather than 'air' and wrote 'isolation' rather than 'insulation'.

Line one caused most difficulty as many candidates did not refer to less blood flowing near the skin surface. Weak answers referred to blood vessels moving away from the surface.

The shivering response explanation often missed out on credit for not referring to muscle contraction but just muscle movement.

Many candidates successfully explained the significance of a reduction in sweat. Some needed to refer to the evaporation of water or incorrectly stated that water loss was reduced rather than heat loss.

(b) Candidates needed to link the surface area effect of curling up to the effect on heat loss.

(c) (i) Some candidates gave explanations about the Sitatunga being warm-blooded and the Nile monitor lizard cold-blooded but here the question asked for a description of the results. Strong answers described the relationship for the Nile monitor; 'as the environmental temperature increases, the monitor's core temperature increases too', but pulled from the graph the general trend of constancy in the core temperature of the Sitatunga regardless of environmental temperature change.

(ii) Many candidates achieved credit for suggesting a disadvantage of the Nile monitor being inactive, with the increased vulnerability to predators being the most popular answer. Some candidates confused the terms prey and predator.

(d) Explaining what is meant by negative feedback was well answered by most candidates. Good answers were either general or used a specific context of a particular homeostatic response, usually temperature regulation.

Question 7

Candidates performed well on this genetics question about blood groups and haemophilia.

(a) Most candidates were able to correctly define a recessive allele. Many definitions of a codominant allele contained errors or omissions. In codominance neither allele is dominant. The answer that codominant alleles are both expressed ideally needs to be qualified by 'in a heterozygous individual'. For the recessive allele the description 'expressed when the dominant allele is not present' was the most common answer.

(b) Most candidates scored full credit. Incorrect answers often had two $\mathbf{I^AI^B}$ offspring genotypes instead of one $\mathbf{I^AI^B}$ and one $\mathbf{I^OI^O}$. Some candidates lost credit for omitting the allele symbol in the gametes row.

(c) Most candidates scored some credit and candidates who were confident with genetics terminology often scored full credit. Most answers stated that a father passes a Y allele to sons and an X allele to daughters. Some candidates included a genetic cross showing the inheritance of the haemophilia allele and referred to X^HY and needed to label the sex of the parent to gain the credit for the male being XY.

Question 8

(a) (i) Most candidates gained credit for naming artificial selection. Incorrect responses included artificial breeding and captive breeding.

(ii) Most candidates gained some credit but few scored fully for a detailed and reasoned account of how selective breeding can be used to improve the milk yield of dairy cows. Candidates generally started by selecting female cows that showed high milk yield to breed and some then selected the best offspring as well. The way in which males are selected for a sex-limited trait by assessing the male's female relatives (progeny testing) was not well known. Strong answers discussed alleles for the high milk yield trait being passed to offspring and increasing in frequency in the population.

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(b) Disruptive selection was a well-known phenomenon but most answers stopped after stating that the two extremes of the distribution are selected for while the intermediates are selected against. Sketch graphs were often seen and needed to have their axes labelled to be useful.

Question 9

(a) Answers showed a good general understanding of the principles of experimental design. Candidates listed a range of variables that needed to be controlled and described how to measure the rate of respiration by timing the colour change of the indicator from blue to colourless. They also stated that the experiment should be repeated so that a mean could be calculated. Experimental details like placing a layer of oil on the surface to exclude oxygen were mentioned in the strongest responses. Many candidates finished by stating that the rate could be calculated using the formula $1/t$ and that a graph could be plotted with glucose concentration on the *x*-axis and either rate or time taken to decolorise the indicator on the *y*-axis.

Some candidates incorrectly changed the concentration of yeast instead of the substrate. Some did not give the name of a suitable substrate, such as glucose. Those who referred to a certain temperature being maintained needed to ensure the temperature chosen was suitable, for example, a temperature between 20 °C and 45 °C.

(b) Candidates responded appropriately to the command word 'compare' and some gave their answer as a convenient table of differences and similarities, with a column for mammalian tissue and a column for yeast cells. Some candidates focused only on differences and omitted similarities. Where candidates described first mammals and then yeast in two chunks of text, they needed to ensure that both 'halves' of the comparison were included, for example that no decarboxylation occurs in mammals while carbon dioxide is produced in anaerobic respiration in yeast.

Question 10

(a) This question invited an account of allopatric speciation. Many answers logically described the sequence of events over time using appropriate subject terminology. Important terms such as 'population' and 'allele' were used correctly. The fact that genetic drift is a separate phenomenon to directed allele change due to natural selection was made clear.

Weaker responses referred to the initial separated populations as species right from the start, which is incorrect. They also made the mistake of referring to genes instead of alleles and confused natural selection with genetic drift. Some did not state that after a long time the separately evolving populations could no longer breed with each other. Weak responses sometimes focused too much on how the separated groups needed to adapt differently, going into detail about problems of different predators, food and climate (i.e. different selection pressures) but giving no information about the processes involved in adaptation at the genetic level.

(b) Candidates were well prepared in listing the main reasons why species may become extinct, with habitat loss, poaching and climate change being the three most frequently mentioned. The potential problem posed by an introduced alien species needed to be explained, for example that it might prey on native species or compete with them. Few candidates made the point that all the risk factors are examples of environmental change and that a species that goes extinct has not been able to adapt to the change quickly enough.

The naming of examples of species that either have gone extinct or which are classed by the IUCN as critically endangered or endangered (the two categories closest to extinction) was poor. The commonest extinct species mentioned were the dodo and the general taxonomic group dinosaurs. Some candidates erroneously stated that elephants and rhinos are already extinct, which is not the case. It is important to use names of species precisely so that it is clear which group of animals we mean. For example, the black rhinoceros (*Diceros bicornis*) is endangered but the white rhinoceros (*Ceratotherium simum*) as a whole is not.
Many candidates wrongly assumed that lions and polar bears are endangered, which they are not. In order to explain why species can become extinct (Syllabus 18.3.1), actual examples in a particular locale need to be used, in order to make real the threats faced by biodiversity and to give candidates an appropriate level of understanding for A level. There is abundant material available online from conservation organisations, and candidates could research a small number of endangered species and the reasons for their decline as preparation for this part of the syllabus.

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Paper 9700/42
A Level Structured Questions

Key messages

1. Candidates should recognise that if the command word in a question is 'discuss' or 'evaluate' then they will be expected to describe both sides of the issue.

2. Candidates need to be aware that when asked to explain a graph or a table they are not expected to describe the information given and should only use figures if it helps their explanation.

General comments

Many candidates performed well and were able to convey knowledge, articulate ideas and effectively analyse data. Novel contexts in questions did not concern able candidates and there seemed to be no pressure of time. The range of marks showed good discrimination between abilities.

Many candidates found **Question 3(a)** to be difficult. **Questions 1**, **7** and **8** for example, were found to be more straightforward.

Comments on specific questions

Section A

Question 1

(a)(i) The components of **Fig. 1.1** were correctly identified by many candidates. Some made the mistake of referring to the pump as a channel protein and a minority confused the two ions. Almost all candidates scored credit in this part of the question.

(ii) Many candidates were able to name substance **C** as ATP although weaker candidates stated that it is acetylcholine or a hormone, or did not attempt to answer the question.

(b) The immediate consequences of the stated drugs on a neuromuscular junction or cholinergic synapse were well described by more able candidates, with many achieving full credit. Weaker candidates repeated the information they had already been given without adding any further detail. The action of curare proved to be the most problematic as, while candidates appreciated that the drug would block the receptors on the sarcolemma so that acetylcholine could not bind, many made the mistake of referring to voltage-gated, rather than ligand-gated, channels opening and sodium ions entering the post-synaptic neurone rather than the sarcoplasm. The effects of nerve gas were well understood with candidates recognising that the inhibition of acetylcholinesterase would prevent the breakdown of acetylcholine so that it would remain bound to its receptors leading to prolonged depolarisation. However, some suggested that acetylcholine might run out in the synapse as it could not be recycled and therefore no depolarisation would take place. More able candidates recognised that if alcohol prevented the exocytosis of neurotransmitter, then it would not be able to diffuse across the synaptic cleft and bind to receptors on the postsynaptic membrane. As a result, the sodium ion channels would not open and there would be no depolarisation of the postsynaptic membrane.

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Some candidates, rather than describing the immediate effects of each drug, stated that action potentials would or would not be formed, while others commented on the movement of calcium ions, particularly when explaining the action of alcohol.

Question 2

(a)(i) The majority of candidates identified at least one use of ATP in movement inside cells. The most frequent response was the sodium-potassium pump and its active transport of ions, possibly prompted by **Question 1**. Some candidates incorrectly provided answers detailing the use of ATP in chemical reactions. It is good practice to select two separate ideas for the two examples; two different versions of active transport would not gain full credit for this question. Many candidates did not focus on cells and answered, for instance, with muscle contraction at an organ level instead of muscle fibre contraction. It is worth noting, when giving exocytosis as an example, that it is incorrect to refer to the exocytosis of vesicles but the candidate should instead refer to the exocytosis of the named substance that is released. More thoughtful candidates were able to draw upon their knowledge from other areas of the syllabus to provide examples. Although less frequently given, the good example of chromosome movement during meiosis was also seen.

(ii) This question required a two-step calculation with the instructions to candidates to show their working and give their answer to the nearest whole number. Overall, this was well answered, with many candidates accurately completing both the calculations and conversion to a whole number. A significant proportion of the incorrect responses had only completed one part of the calculation, resulting in 6.25 or 750 as the final answer. Some candidates who had correctly completed the calculations did not give the answer to the nearest whole number, or incorrectly rounded to 32.

(iii) This was a straightforward question with the majority of candidates gaining full credit. It was important to give the specific versions of phosphorylation and a small number of candidates did not include the prefix 'photo' for the example of chemiosmosis in photosynthesis. A minority did not select a stage in respiration but instead provided a site of ATP production, giving the electron transport chain as their answer.

(b)(i) This question provided an unfamiliar context of mitochondria adaptation for some mammals to survive cold external temperatures. Candidates needed to examine the information from the diagram in **Fig. 2.1** and then describe and explain how the transport protein thermogenin affected ATP production. Many responses used the term diffusion to describe the movement of protons down their concentration gradient, which was evident from the diagram. Successful candidates then linked this diffusion of protons to a decrease in the number of protons diffusing through the ATP synthase, finally concluding that this would reduce ATP synthesis. A significant number of candidates just explained how ATP was synthesised and did not incorporate the role of thermogenin in this context, so did not achieve credit. Some candidates incorrectly deduced that ATP synthesis would increase either due to a higher temperature or due to the movement of protons through thermogenin having increased the number of protons available to be pumped into the intermembrane space.

(ii) The majority of candidates, across a broad range of ability, demonstrated a good grasp of this form of cell signalling and were able to access full credit. Responses generally flowed well, related the correct sequence of events and used key scientific language effectively. Many of the weaker responses used phrases provided in the question information or stem of the question and did not seem able to qualify the details of the signalling process. To improve, candidates should be specific when describing the location of a protein receptor as being on the cell surface membrane rather than simply on the cell membrane.

Question 3

(a)(i) Many candidates found it quite difficult to list three correct features shared by animal species. Some simply described features of a eukaryotic cell while weaker candidates named the characteristics shared by organisms of a single species. Stronger candidates understood that all animals are heterotrophic and multicellular, with cells specialised into tissues and organs. A few stated that animals are motile and have a nervous system and there were very occasional references to small, temporary vacuoles or vesicles within animal cells.

(ii) This was a challenging question, which required candidates to think about a topic from a different angle. Explanations as to how the classification of species into a taxonomic hierarchy assists the

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work of conservation bodies were often vague. Some described the mechanism of classification of organisms into the different taxa and how it would enable people to distinguish the various species. A few responses commented that classification would record biodiversity, although more candidates recognised that endangered species could be identified and a conservation plan could then be devised to protect them, such as captive breeding, national parks or nature reserves. Very few references to the taxonomic hierarchy being internationally standardised were seen.

(iii) The most able candidates were able to discuss persuasively whether the increase in numbers meant that the named classes of chordates were being successfully conserved. While some stated that the increase in number of species signified that conservation had been effective, few referred to an increase in biodiversity. Some tried to explain the increase in numbers by suggesting that there had been a decline in predators or that more food or better habitats were available. A minority of candidates recognised that while there were more species overall, this did not necessarily mean that these species had large populations since the number of individuals within each species had not been assessed. A few suggested that the methods of classification had become more accurate so that organisms with very similar characteristics could be separated into more than one species, or that the number of new species being discovered was greater than the number becoming extinct.

(iv) The percentage of species belonging to the most diverse animal class was correctly calculated by many candidates although some needed to round up correctly and express their answer to two significant figures to achieve full credit. Some chose the wrong figures such as dividing the number for insects by that of arthropods, or arthropods divided by the total number of animals, but were able to gain some credit if the calculation was correctly done with the incorrect numbers, and the answer given to two significant figures.

(b) (i) The majority of candidates were able to outline at least one factor that could cause populations of insects to decrease in size in developed countries. Loss of habitat or deforestation were the most common responses and many candidates also appreciated that the use of pesticides or insecticides would lead to population decline. Disease and predation were occasionally mentioned and a few referred to a new disease or an increase in predation.

(ii) Higher achieving candidates appreciated that only the insect pest eating the crop plants would be killed by the Bt toxin, obviating the need for pesticides or insecticides and so benefitting biodiversity. Many responses erroneously centred upon the survival and proliferation of the crop plants themselves or their hybridisation with other plants to produce new species. A very few responses commented on the survival of insect pollinators.

Question 4

(a) Few candidates gained full credit for this question. For the first part, requiring an understanding of the production of recombinant therapeutic proteins, many responses described the use of vectors and needed to go on to refer to the use of bacterial cells in insulin production to gain credit. Some incorrectly introduced ideas about gene therapy. Fewer responses gained credit for the second part, which was awarded for simply stating gene therapy, by incorrectly elaborating on the process. For example, a common misconception was to provide incorrect details such as using a functional allele to replace a gene/allele.

(b) (i) Generally, candidates scored well on this question, correctly describing that GM spinach plus buffer decreases or has the lowest number of bacteria at all times and that the longer the time stored the more effective it is. However, fewer candidates correctly gave an accurate data quote comparing GM spinach extract with either no treatment or buffer alone as there was a tendency to quote data just for the spinach treatment over time, rather than comparing it with buffer or no treatment. Few candidates provided any arguments for the results not being valid such as the fact that the number of bacteria decrease with no treatment or that the data does not test the effect on people.

(ii) A majority of candidates described the possible risk on human health of allergies or side effects caused by this application of recombinant DNA technology. The possibility of the bacteria developing resistance to the colicins was also mentioned frequently. Fewer responses mentioned the possible effects on the taste or quality of the meat or the effect on other beneficial bacteria in the gut. Some vague answers were seen, referring to religious or moral objections without any context or the potential cost of the treatment, which did not gain credit.

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Question 5

(a) (i) This was a straightforward question with the majority of candidates providing correct responses for both parts. Common errors included CO_2, NADP, NAD(H), FAD(H), oxygen and water.

(ii) Many candidates were able to gain full credit in identifying the role of chlorophyll b as being an accessory pigment and to absorb light. The most able candidates included all the possible responses with the specific detail required, for example, passing on the energy to the primary pigment and that it absorbs wavelengths of light not absorbed by the primary pigment. Weaker responses confused the chlorophylls and incorrectly identified chlorophyll b as a primary pigment with the resulting description. Many candidates confidently used the term 'absorb' with reference to light instead of 'traps' or 'captures', which were not creditworthy.

(b) Almost all candidates who gave an answer did so correctly. A very small number did not provide an answer.

(c) (i) Candidates were provided with a graph of results in **Fig. 5.1** which they needed to use to state the range over which light intensity is the limiting factor and to go on to explain why light intensity above their given range is not limiting the rate of photosynthesis. The majority of candidates gave the correct range; the few who answered incorrectly usually stated 100–400, or gave a single figure instead of a range. Many candidates correctly identified the factors that would be limiting above 400. Weaker responses defined the term limiting factor, rather than explain why light intensity was not a limiting factor above this range.

Many missed the term concentration when referring to carbon dioxide, but still managed to gain credit by referring to temperature. There were few attempts to explain how temperature or the concentration of carbon dioxide would limit photosynthesis. Candidates did not refer to kinetic energy, or comment on fixation of carbon dioxide.

(ii) This question was quite challenging and few candidates gained full credit. It required an explanation as to why different colour filters result in different rates of photosynthesis.

A common response focused on white light as being absorbed the most, with a large proportion identifying that white light comprised all coloured light, linking this to the higher rate of photosynthesis with an additive effect. This type of response did not directly answer the question. Few candidates went on to explain the differences in rates when using the different colour filters. Weaker candidates focused their response on the absorption of light by filters and the linking of photosynthesis with colour filters to the number of bubbles released, which was not required.

The most common correct answer was a reference to green light being reflected, although some incorrectly thought that no green light could be absorbed. Very few candidates accurately identified red light as being absorbed the most, with many incorrectly stating that red and blue light were together absorbed the most. Only a minority of candidates made the extended links between wavelength and energy. Very few candidates linked the greater absorption to named stages of photosynthesis, for example the light dependent stage or photophosphorylation.

Question 6

(a) (i) This question was generally well answered with most candidates correctly giving protein or glycoprotein as their answer.

(ii) The majority of candidates correctly stated that a hormone is transported through the blood system.

(b) Candidates were required to state or describe the processes of glycogenolysis and gluconeogenesis, however, a minority got the two process names correct. Some who correctly spelt the processes then went on to give a false description. It is worth noting that correct spelling is essential for this part of the syllabus where many molecule and process names are similar.

(c) On the whole this question was not answered well. Few candidates mentioned that the effect would be to reduce the intake of food.

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(d) Many candidates achieved full credit here and the majority gained some credit. Some candidates knew that negative feedback was about returning a parameter back to the set-point or normal value but did not then outline the sequence of events.

(e) The majority of candidates gained most of the credit available, usually by referring to a frameshift and a changed polypeptide. However, many then lost out by confusing the structure of the transcription factor with the gene for GLP-1. Higher achieving candidates were able to gain full credit by correctly identifying that the transcription factor would become non-functional and stating the effect this would have on GLP-1 production.

Question 7

(a) Most candidates gained credit by referring to an allele as a variation of a gene. Responses describing dominant were often confused and imprecise.

(b) (i) Overall, this was a high scoring question with the vast majority of candidates scoring full credit. A small number clearly did not understand the difference between genotype and phenotype and consequently gave all their answers either using descriptions or symbols.

(ii) Many candidates understood that the irregular distribution of offspring phenotypes was due to the linkage of genes. Higher ability candidates scored well, mentioning recombinant phenotypes being due to crossover during meiosis and noting that the recombinant phenotypes were in a much smaller number than parental phenotypes. Weaker candidates found this question more challenging with many writing about homozygous and heterozygous crosses and dominant alleles being expressed. A few candidates had the misconception that there was independent assortment taking place.

Question 8

(a) A small number of responses achieved full credit for their understanding of the genetic basis for continuous variation. Some candidates referred correctly to the contributory role of multiple genes and could then link this to the idea that these genes had an additive effect on the phenotype. A minority mentioned different alleles at a single gene locus having small effects on the phenotype. Many candidates confused the terms alleles and genes, referring to genes having small effects or multiple alleles being involved. A large number of respondents did not mention any genetic basis for continuous variation and instead largely wrote about the importance of environment on variation, which did not answer the question posed.

(b) Many candidates correctly listed two examples of environmental factors affecting body mass, such as the quantity and quality of food, disease or temperature. Credit was lost in some cases with vague answers such as ‘climate’ or ‘diet’ without any further qualification in the response. Many incorrectly believed that exercise was an important environmental factor.

(c) The majority of candidates had a very good understanding of selective breeding and were awarded full credit for this question. Where credit was lost, it was for describing selecting alleles or genes rather than selecting desired characteristics or traits – suggesting a lack of awareness of how long selective breeding has been used as a process compared to our relatively recent knowledge and application of genetics. Others mistakenly mentioned breeding only parents together for many generations rather than progressing to the subsequent selection of offspring with desired characteristics and breeding those offspring. Few candidates mentioned humans acting as the selection pressure and although inbreeding depression was occasionally mentioned, the idea of using outbreeding to avoid inbreeding depression was seldom seen.

Section B

Question 9

(a) The majority of candidates began by stating that the mitochondrion is a double membrane bound organelle responsible for the production of ATP to provide energy for the cell. Many continued by describing the folding of the inner membrane into cristae to increase the surface area so that more ATP synthase complexes, electron transport chains and proton pumps could be accommodated. Some also commented that the more active the mitochondrion, the more cristae it would have, in order to maximise ATP synthesis.

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Many candidates then described the processes taking place in the mitochondrion, such as the pumping of protons into the intermembrane space resulting in a high proton concentration and the establishment of a proton gradient between the intermembrane space and the matrix. There was frequent mention of the diffusion of protons through ATP synthase providing the energy to synthesise ATP from ADP and Pi during oxidative phosphorylation or chemiosmosis. However, descriptions of ATP synthase pumping protons were not credited.

References to the Link reaction and Krebs cycle occurring in the matrix were common, although only occasionally did candidates mention the presence of the enzymes or coenzymes required for these processes. Similarly, while candidates understood that ribosomes and circular DNA would be found in the matrix, few linked this to protein synthesis within the mitochondrion.

There were a number of vague statements about the permeability of the inner and outer membranes, and although some candidates commented that the outer membrane is permeable to substances, few named oxygen, pyruvate or reduced NAD. Very few responses mentioned that the inner membrane is impermeable to protons.

Common mistakes were to confuse the location of either the various structures or the processes taking place within the mitochondrion. Some weaker candidates also stated that glycolysis would occur in the matrix.

(b) There were some excellent accounts of the adaptations of rice to growth in water, with many candidates providing creditworthy statements in excess of that required to gain full credit. There were also some very vague responses which attracted little or no credit.

Many candidates stated that the rice plant contains aerenchyma tissue, although only a minority recognised that it is found in both the roots and the stem or that it functions to convey oxygen to the shallow roots. Nevertheless, many appreciated that anaerobic respiration, or alcoholic fermentation, will take place in the submerged parts of the plant with limited oxygen supply, resulting in the generation of ethanol. There were also frequent references to the presence of ethanol (alcohol) dehydrogenase enabling the roots to be tolerant to a high concentration of ethanol.

Stronger candidates understood that an increase in ethanol triggers an increase in ethene and gibberellin which, in turn, stimulates the growth of the stem so that the flowers and leaves are above water. However, while weaker candidates appreciated that stem elongation will take place, they provided no further detail. Some also described the ridged leaves which enable a layer of air to be trapped but neglected to add that these leaves would be underwater.

Question 10

(a) Many candidates demonstrated sound understanding of the topic and were able to link the different types of gene mutations to how they can affect the phenotype, including references to frameshift, STOP codons, changes to primary and tertiary structure and the effect on the functioning of the protein. It was common to see a mention of how a base substitution mutation was less likely to have a significant effect on the phenotype (as in silent mutations) but the detail that a frameshift mutation was likely to have a significant effect on the phenotype was rarely mentioned.

Candidates generally gave good outlines of the effects of the mutant alleles that cause Huntington's disease on the phenotype of a person. Common answers included the knowledge that it is a dominant condition and onset of disease is in middle age. Although many candidates gave the idea of CAG repeats, some incorrectly wrote that the person has more CAG repeats instead of the allele. Very few identified that heterozygotes are affected or linked the disease to the effect on brain cells. Symptoms frequently quoted were involuntary movements and mood changes.

A few responses focused on only one section of the question, while others described mutations using other diseases, such as cystic fibrosis or sickle cell anaemia: both of these approaches limited the credit that could be awarded.

(b) This part of the question produced a range of responses. The context of gibberellin action on DELLA proteins proved to be quite challenging. Many answers correctly identified the aleurone

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layer as the location for gibberellin activity. However, as the actual process covers a number of stages it was evident that some candidates confused the sequence of gene control. The most common incorrect response was that gibberellin was directly involved in breaking down DELLA protein by binding to it, rather than it binding to a receptor which activates the enzyme to break down DELLA proteins to allow the binding of PIF, the transcription factor, to bind to the promoter. While some candidates correctly stated transcription of the gene coding for amylase, very few followed this with translation leading to amylase production. Candidates should always make sure that they describe a gene being transcribed. Many incorrectly stated that amylase (a protein) was transcribed. Accounts that were set out in a clear and logical order tended to achieve the most credit. A minority of responses showed some confusion with the bacterial lac operon, with references to repressor proteins and the operator.

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Paper 9700/43
A Level Structured Questions

Key messages

Candidates should be encouraged to deal with data analysis in a methodical way in their responses, such as in **Question 6(b)(i)**. They should make a point of describing each set of data, look to make comparisons between the data sets and quote data to support the points they have made.

General comments

This paper was very accessible to the majority of candidates. Candidates found some questions more challenging than others, for example, **Questions 2(b)**, **3(c)**, **4(a)** and **4(b)(i)**, **5(b)(iii)**, **6(a)(i), 8(a)** and **8(c)** and **9(a)** and **9(b)**.

Candidates should pay particular attention to questions which require them to make a comparison. It is important to make a direct and clear comparison for each point, as in **Question 5(a)** and **Question 10(b)**. Sometimes, putting answers in a table is a good way to achieve this.

Comments on specific questions

Section A

Question 1

Many candidates made a strong start on the paper by gaining most of the credit available in **Question 1**.

(a) Most candidates were able to correctly name the four structures shown on the diagram. A minority found it difficult to transfer their knowledge to **Fig. 1.1** and consequently did not score highly. Good use was made of correct terminology. A small number of candidates made errors with the spelling of troponin and tropomyosin and also confused the two terms.

(b) Many candidates were able to show that when calcium ions are released from the sarcoplasmic reticulum, they bind to troponin causing tropomyosin to move and make the binding site available for the myosin head to bind. Weaker candidates tended to give a short answer or leave this part blank. A few candidates missed out on credit by referring to myosin binding to actin and not more specifically referring to the myosin head binding to actin.

(c) This question required candidates to suggest why muscles remained contracted after death, based on their knowledge of the sliding filament theory. A good response would be to state that little ATP would be formed and consequently cross bridges would not break, leaving the muscle contracted. A minority of candidates were able to achieve full credit.

Question 2

(a)(i) Most candidates correctly identified the mechanism for maintaining ionic concentrations in cells as active transport.

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(ii) Candidates were required to show their working for a two-step calculation to find percentage efficiency. Most candidates showed all stages of their calculations as instructed, however, a small number of candidates only included one step of their calculation, so could not be awarded full credit. Nearly all candidates reported their final answer to a number of significant figures appropriate to the data provided, meaning that candidates across all abilities achieved credit for the correct answer after using the correct method.

(iii) This was a synoptic question requiring candidates to think about homeostasis and that the process of thermoregulation uses the heat energy released during respiration. Most candidates achieved credit in this question and the more able used the correct term of thermoregulation. However, many candidates opted to describe the process of thermoregulation and some lower achieving candidates missed out on credit due to a weak description. It is important to be specific that it is the core or body temperature that is being maintained. It is good advice to avoid the term 'regulation' in homeostasis and opt for the better term 'maintenance' as homeostatic mechanisms work to keep the parameter at or around a set level (maintenance) as opposed to regulation which generally means how an organism adapts, usually by a rate change, to a changed condition.

(iv) The majority of candidates demonstrated that they understood that the Krebs cycle produced ATP by phosphorylation. Many responses needed to be more specific to achieve the credit by highlighting that it was substrate-linked phosphorylation. Some weaker candidates mistakenly wrote that it was oxidative phosphorylation.

(b) This question was generally poorly answered with only a minority of candidates showing that the RQ can be used to deduce the respiratory substrate that an organism is using. Candidates were expected to use the graph in **Fig. 2.1** to read off the RQ and suggest the respiratory substrates used or the type of respiration taking place. Few were able to provide a correct answer for the RQ of 0.8 when at rest. Some candidates were able to work out that lipids were being respired but not that this would be part of a mix of substrates. More candidates knew that an RQ of 1.0 meant that the respiratory substrate was carbohydrate. A good number of responses correctly stated that an RQ of 1.2 meant that anaerobic respiration would be occurring due to the decreased availability of oxygen.

(c) The majority of candidates correctly used the term oxygen debt to explain the continued deeper breathing at a higher rate after a person has stopped exercising. Very few responses went on to explain that the extra oxygen gained this way was used to convert lactate to pyruvate or glycogen, or that the haemoglobin in red blood cells would be re-oxygenated.

Question 3

(a)(i) Many candidates were able to apply their knowledge about the concept of a species to the context given. The most common answer seen was that the groups of flies originally classified as separate species were geographically isolated. Another common answer was that the different groups had differences in morphology. Some candidates did well to demonstrate knowledge that there could have been differences in physiology, biochemistry, genetics, and behaviour or that they occupied a different ecological niche.

(ii) The majority of candidates knew that a simple investigation would involve mating individuals from the different groups of species of flies together and to follow that up by seeing if the offspring can interbreed successfully as well. A rarely seen correct answer was to describe the use of bioinformatics and utilising the data available. A few candidates did not take into account that the investigation had to be simple and suggested taking DNA samples and the use of gel electrophoresis and complicated genetic analysis.

(b) Many candidates were not confident with the different kingdom and domain names. The majority of candidates answered with the domain names of either Bacteria or Eukarya rather than two kingdoms that were asked for. This was evident in scripts across the ability range. Candidates should take care in naming the kingdom that contains bacteria as Prokaryotae. Kingdoms Fungi and Protoctista were also correct answers for this question.

(c) This question directly asked for knowledge and understanding of alien species which is a learning outcome on the syllabus. Many stronger candidates showed that they had learnt this material and succinctly explained at least four reasons why the introduction of alien species should be avoided.

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(d) This question was well answered by the majority of candidates, who realised that the reclassification meant that the ban would be lifted allowing exports to proceed, which would be an economic benefit.

Question 4

This question was about genetic engineering and candidates generally found the topic matter and context difficult.

(a) Candidates across the ability range found this question challenging. The question drew on knowledge and understanding directly from the syllabus by asking for an outline of the genetic engineering process. The context was to produce Bt maize plants with resistance to insect attack. It was clear that the higher ability candidates did not recall that the gene required came from *Bacillus thuringiensis*. Instead, many suggested that the gene was acquired from other plants that resisted insect attack. More candidates could recall the general procedure starting with the use of a restriction enzyme to cut out the gene, the cloning of the gene via PCR, inserting the gene into a plasmid and adding a promoter, and finally sealing the gene and plasmid using DNA ligase. Some candidates knew that the recombinant plasmid was introduced to maize cells or embryos. A few candidates finished their answer with the maize expressing the newly introduced gene and that the gene product would be Bt toxin. Some common mistakes were to describe that it was mRNA and not DNA that was added to the plasmid, that the recombinant plasmid was added to seeds not cells and the incorrect use of reverse transcriptase.

(b)(i) Candidates generally found this question a straightforward interpretation of the graph in **Fig. 4.1**. Most were able to state a suitable conclusion using the data in the graph. Some candidates were not awarded credit as they simply used data and described the trends instead of making a conclusion.

(ii) This was a novel question with a synoptic element that most candidates found very challenging. A scenario was given whereby the predicted decrease of the numbers of monarch butterflies based on the lab experiment did not occur in the real ecosystem. Candidates had to use the data about caterpillars from **Question 4(b)(i)** and apply their knowledge of a real ecosystem as to why the predicted decrease did not occur. The most common answers given were that the Bt pollen did not get deposited onto the milkweed plants and that the caterpillars and Bt maize were located in different areas. Only a very small number of candidates hypothesised that the pollen may be released at a different time to when the caterpillars feed. A good number of candidates got the idea of resistance developing, however, many did not make the connection that it was important to state that it was the caterpillars, not the butterflies, that would have the resistance to Bt toxin as they ate the milkweed leaves.

Question 5

(a) A good number of candidates knew the differences between cyclic and non-cyclic photophosphorylation. Direct comparisons must be clearly made for credit to be awarded in questions asking for differences to be described.

(b)(i) Many candidates knew that test-tubes 1 and 5 were control tubes. A few candidates were able to explain their purpose as being used for comparison with the other tubes to be able to interpret the results.

(ii) Candidates needed to use the information from **Fig. 5.1**, **Fig. 5.2** and **Table 5.1** to be able to successfully answer this question. The majority of candidates used their skills of analysis, interpretation and deduction to work out that in test-tube 2, containing only a plant, the plant would be photosynthesising and using up the carbon dioxide and thus with less carbon dioxide in the water the pH would be increased. For test-tube 3, containing the pond snail, the pond snail would be respiring and producing carbon dioxide, thus the pH of the water would decrease. Lastly, that in test-tube 4, containing both a plant and pond snail, both photosynthesis and respiration would be occurring and thus the carbon dioxide produced in respiration would be used in photosynthesis and no pH change would be detected.

(iii) Many candidates were correctly drawn to the significance of the yellow-green result of test-tube 6 indicating that the plant kept in the dark would no longer be photosynthesising. Some candidates gave additional detail here and explained that this would mean the light dependent stage would not

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occur. Many recognised that the plant would still be respiring and producing carbon dioxide. A minority of candidates worked out that plant respiration was slower than animal respiration and were able to articulate that with the respiration rate being slower in test-tube 6 when compared to test-tube 7, this would result in a slight decrease in pH as seen by the yellow-green result.

Question 6

(a)(i) This question required candidates to suggest why the arrangement of blood vessels in a flipper of a bottlenose dolphin enabled it to conserve body heat. Very few were able to explain that heat from outgoing blood in the arteries would be transferred to blood in the incoming veins.

(ii) Stronger candidates were able to show that in order to lose heat dolphins' blood vessels would dilate. Many candidates were able to use the correct term of vasodilation. A few responses lost credit by contradicting their answer, incorrectly stating that the capillaries dilated or that the blood vessels moved to the surface of the skin. Another correct answer was that the dolphins would have a behavioural response such as diving down to cooler water.

(b)(i) The graph in this question showed the effect on blood insulin concentration on dolphins being given food with an additive of glucose or no food at all. A strong candidate would notice that the insulin concentration in the fed dolphins would increase and that it would stay fairly stable in the dolphins that had not been fed. Some candidates were able to describe the graphs clearly whilst others tried to explain what was happening, which was not required. The most successful technique to answer this question was to methodically take each set of data and describe it and then to compare it to the other two data sets. Many candidates were not accurate enough with their paired data quote or did not provide the correct units.

(ii) This question asked candidates to calculate the rate of change in the increase in insulin concentration in dolphins that had been fed 11 g of glucose per kg of fish. They were required to read correct figures from the graph. Few candidates were able to carry out this task accurately. One repeating trend was for candidates to make a rounding error and incorrectly round 0.766 to 0.76 instead of 0.77.

(c) Many candidates were able to give a clear and concise explanation of negative feedback. Candidates should be encouraged to always use the correct terminology, such as receptor, coordination, effector and set point.

Question 7

(a) Candidates were mixed in their response to this question about the phenotypic effects of having sickle cell anaemia. Stronger responses stated that the abnormal haemoglobin would stick together thus pulling the red blood cell into a sickle shape. This would result in a reduction in the oxygen carrying capacity of the blood and lead to pain and fatigue. Common errors included a confusion that the haemoglobin would be pulled into a sickle shape and that the haemoglobin would get stuck in blood capillaries.

(b)(i) A majority of candidates were able to show that in codominance both alleles would be expressed in the phenotype in a heterozygous condition.

(ii) Many candidates were able to suggest a reason why people with sickle cell trait did not show the symptoms of sickle cell anaemia, such as there being less abnormal haemoglobin or fewer red blood cells becoming sickle shaped.

(iii) Most candidates were able to carry out this genetic cross between two people with sickle cell trait. It is important to note that some credit was lost due to a lack of clarity when describing the offspring phenotypes. Some mistakenly suggested that sickle cell anaemia was sex-linked and gained no credit.

Question 8

(a) Candidates were asked to explain what is meant by stabilising selection. A small minority gave an answer stating that individuals in a population with an intermediate phenotype would survive whilst those at the extremes would not. Very few candidates recognised that in stabilising selection there is no change in the environment. Common mistakes in this question included not correctly

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referencing individuals and whether they survive or not but incorrectly suggesting that some alleles are more likely to survive and reproduce.

(b)(i) Many candidates were able to suggest that due to poor camouflage the white and black mice were more likely to be eaten by predators and thus their numbers would fall.

(ii) Candidates were required to draw a curve to show how numbers of mice in a population would change if an environmental factor, the colour of the soil, also changed. Many drew a correct curve in terms of the location of the peak and the majority of these also decreased the width of the curve.

(c) This proved to be a difficult question with few able to show that genetic drift is a random change in allele frequency and only has a large influence in a small population.

Section B

Question 9

(a) Candidates needed to explain the use of genes for fluorescence as markers in gene technology. Most candidates provided an answer that lacked detail. The most common points covered were the use of UV light and how fluorescence indicated that the organism contained recombinant DNA. Improvements could have been made in examination technique by giving more carefully ordered and detailed responses.

(b) Candidates achieved higher credit on this part of the question discussing the social implications of using genetically modified organisms in food production. The most commonly seen creditworthy points were the identification of disadvantages like consumer resistance to GM crops, safety aspects for humans, as well as it being expensive. A few candidates were able to discuss some positive aspects, for example, an increase in yield or improved food quality.

Question 10

(a) Candidates were asked to describe the roles of sodium ions in selective reabsorption in the nephron and calcium ions in the functioning of a cholinergic synapse. Some were able to show the role of sodium ions in the cotransport of glucose. A greater number of responses demonstrated knowledge of a cholinergic synapse and good levels of credit were achieved here.

(b) Candidates showed a good knowledge of both the nervous and endocrine systems. They were generally aware of the need for a comparison between the two systems and some drew a table which helped to ensure important points were not missed. On the whole this question was well answered. One area for improvement for some candidates would be to ensure direct comparisons are made for each point.

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Paper 9700/51
Planning, Analysis and Evaluation

Key messages

Candidates are advised to read through all of the questions on the paper before starting to write so that their answers can be carefully structured to meet the specific requirements of each question.

Evaluation of the results of an investigation is one of the skills tested. Candidates must make sure they do more than simply state the results of the investigation. An analysis of the extent to which conclusions drawn can be fully justified is required. Those candidates who have practiced this high-level skill are more likely to perform well on these questions.

General comments

There was a good range of responses with many excellent scripts. There was no evidence that candidates were short of time on the paper.

In general, the material on the chi-squared test was well handled and showed a good understanding.

Comments on specific questions

Question 1

The common theme in this question was based around inhibitors. The first part of the question involved the enzyme β-galactosidase which catalysed a reaction where there was a colour change. The intensity of this colour change could be measured using a colorimeter. Candidates were asked to consider how to dilute the enzyme and to design an experimental method to assess the effect of an inhibitor on the initial rate of the reaction catalysed by this enzyme. This was followed by a section testing their understanding of the types of enzyme inhibition. The final part of **Question 1** moved into a different aspect of biological inhibition involving control of gastroesophageal reflux disease.

(a) Candidates were asked how to dilute a stock solution of the enzyme by a factor of 20. This was a different approach to asking how to achieve a given dilution and many candidates found this question difficult. Good answers showed a realisation that to achieve 10 cm^3 of a 1 in 20 dilution requires 0.5 cm^3 of the stock solution and 9.5 cm^3 of the buffer solution (or equivalent ratios from which 10 cm^3 were extracted). Common incorrect responses were to give a 1 in 2, 1 in 10 or 2 in 8 dilution, or to make general statements like 'by proportional dilution' or 'use C1V1 = C2V2 to get the concentration you want', without giving any actual volumes.

(b) This section provided candidates with some information to be used in the planning exercise in **Question 1(c)** as well as testing certain aspects of experimental design.

(i) Most candidates were able to convey the idea that the colorimeter gave a quantitative measurement of the intensity or absorbance. This was expressed in many ways with 'more accurate' or 'more precise' or 'objective' being common creditworthy approaches. Some responses were too generalised such as it being 'hard to judge colour by eye' with no qualification with regard to intensity.

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(ii) This was usually well answered. The commonest error for the independent variable was just to write ONPG/substrate rather than its concentration. A few candidates confused ONPG with β-galactosidase. For the dependent variable (absorbance), credit was allowed for the intensity of the yellow colour. References to the rate of absorbance were rejected.

(c) (i) There was quite a range of responses to the planning exercise. The strongest responses were set out clearly with a logical sequence of steps that would achieve the aim of the investigation. Some of these higher-achieving candidates may have benefitted from attempting to follow some instructions produced by a fellow candidate throughout their course as a means of helping them learn what makes a clear plan.

The first stage was to make a sufficient number and range of substrate concentrations. There needed to be at least 5 concentrations and the range should not have started above 1% as that was the concentration of the stock solution of ONPG provided. Units for the concentrations were important and as the stock solution was 1%, values given as mol dm^{-1} were not acceptable.

In this exercise, it was important to use the materials and information provided correctly. A few candidates confused the substrate and enzyme and diluted the β-galactosidase. Reference to standardised stated volumes of enzyme, substrate and inhibitor were creditworthy. For the enzyme and inhibitor, standardised concentrations were an alternative way to achieve credit. Most candidates realised that, as an enzyme reaction was involved, it was necessary to carry out the reaction in a named temperature-controlled environment like a water-bath. Fewer used the information provided and suggested a method for keeping the enzyme cool prior to the reaction. It is good practice to bring the enzyme and substrate to temperature and this gained credit provided it was clear that such equilibration occurred before mixing.

This investigation was to measure the initial rate of reaction and thus it needed to be clear that the absorbance should be read no later than 2 minutes after the reactants were mixed. There were many good answers making this point. Some candidates were confused and thought they were expected to follow the course of a reaction and thus suggested taking readings at a series of time intervals until something like an end-point was reached or the colour changed. This was not appropriate. Replicating the experiment was often well-covered and the correct use of the term 'mean' rather than 'average' is increasingly commonly seen. There were a number of inappropriate suggestions for controls such as with no enzyme or boiled enzyme. If the aim of the investigation is to be achieved, it is valid to repeat the whole series of ONPG concentrations in the absence of inhibitor **X** (in effect the experiment in **Question 1(b)**) in order to compare the initial rate with and without inhibitor **X**.

Candidates should structure their risk assessment on the basis of identifying a precise hazard, a risk associated with that hazard and a linked precaution. Just stating low or medium risk unqualified is not enough to gain credit. Thus, as an example, the enzyme may be a hazard with the risk of an allergic reaction and the precaution would be suitable protective clothing such as masks or gloves. In this example, considering just 'the solutions' or 'the chemicals' was not enough. Something specific to the investigation needed to be identified.

(ii) The great majority of curves were correctly drawn to the right of the original and a majority showed a curve appropriate for a competitive inhibitor by reaching the same V_{max} as the curve without inhibitor **X**. A significant minority drew a curve for a non-competitive inhibitor which only allowed access to some credit. Curves that very closely followed the original curve throughout or started well along the *x*-axis gained no credit.

(iii) V_{max} was correctly identified on the *y*-axis by a large majority. K_m was identified correctly less often. K_m must be shown on the *x*-axis (not on the *y*-axis which would indicate $^1/_2\ V_{max}$ or as a dot on the curve). Some responses incorrectly labelled it on the *x*-axis by wrongly working out $^1/_2\ V_{max}$.

(iv) The question asked candidates to use their graph to describe the effect of the inhibitor on the K_m. Credit was not given for just a theoretical answer. If the curve had been sketched correctly in **Question 1(c)(ii)** for a competitive inhibitor then the value for the K_m would increase.

(d) Data on aspects of gastroesophageal reflux disease control by two different methods were provided and the candidates were asked to discuss the conclusion that PPIs should be used to treat the condition rather than H_2RAs, with reference to the data provided. An evaluation was

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required on how far the conclusion can be justified from all the information provided. The strongest answers not only pointed out that PPIs showed greater success with both reduction and removal of symptoms, but also were able to indicate that there were a range of other things that needed to be taken into account to be sure this was a valid conclusion. The data included 95% confidence interval error bars. Relatively few mentioned these, and candidates were not always clear on what can and cannot be concluded from such error bars. In the early weeks where the error bars do not overlap, this only suggests that the difference could be significant. A statistical test such as a *t*-test needs to be carried out to compare the data and see if the difference is significant. In the later time period there is an overlap of error bars so the difference in effect is not significant. Amongst other ideas credited were the lack of any idea of the possible side effects of the two treatments, the fact that in the long term the H_2RAs might be better and a lack of any evidence of the relative sizes of the two test groups or their previous medical history.

Not all candidates appreciated that evaluation required this sort of approach and limited their answers to lengthy descriptions of the data which simply reiterated their original statement on the treatment of acid reflux. Evaluation is a higher-level skill that candidates should improve with practice during their preparation for this examination.

Question 2

This question tested candidates' understanding of the use of the chi-squared test in the analysis of genetics data. It was important that the information at the start of the question was carefully read and understood for responses to be successful. Many candidates realised this and followed a clear path through the steps required to answer each section. Less successful candidates became confused at an early stage.

(a) (i) Many candidates were able to gain credit here by the idea that the chi-squared test allowed the observed and expected data to be compared to see if there was a significant difference. Some responses mistakenly suggested that the test was used because there was a difference and another fairly common response which did not gain credit was to suggest that it was to test if there was a correlation between the expected and observed data.

(ii) The majority of candidates gave a clear null hypothesis stating that there was no difference between the observed and expected results. A few were confused by this and gave the alternative hypothesis and did not gain credit.

(iii) Many candidates gained credit for the column headed **E** but some thought a 1:1 ratio was expected and gave the same value for all four rows. Others just put down 9:3:3:1 rather than the ratio as applied to the sample size of 3345. Many had worked out the final column correctly and expressed each value to the same number of significant figures. Credit was lost for variable numbers of significant figures or incorrect rounding.

(iv) Most candidates correctly selected 7.82 as the relevant critical value. A few lost credit by quoting the degrees of freedom, their calculated chi-squared value or a figure that did not appear in the table.

(v) Good answers clearly stated that the null hypothesis was rejected as the calculated value was higher than the critical value of 7.82. This meant that there was a significant difference between the data. The conclusion from this regarding the inheritance of these genes is that they are linked/found on the same chromosome. Some candidates suggested that the calculated value being higher than the critical value meant that the null hypothesis was accepted which meant only limited credit was possible if the next steps were logically followed.

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Key messages

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

General comments

The responses covered the full range of marks and there was no evidence that the candidates were short of time on this paper.

Comments on specific questions

Question 1

(a) Many candidates correctly identified the independent variable as copper(II) sulfate concentration and the dependent variable as the volume of oxygen.

(b) (i) The question asked how a suitable range of solutions could be made by serial dilution of the $0.04\,mol\,dm^{-3}$ copper(II) sulfate solution. Many candidates were able to correctly state at least five different concentrations that they would make. Fewer candidates were able to provide a suitable method for making these concentrations, with many writing instructions for making one concentration and then saying they would repeat this method. Details of how to make at least two intermediate concentrations were needed for candidates to fulfil the requirements for making a range of concentrations. Those candidates who presented their answer in a table were more likely to gain full credit for this question. Few responses described how to make a range of solutions using a proportional dilution method instead and therefore were not able to gain full credit.

(ii) There were many clear and detailed plans which gained full credit. Less creditworthy responses tended to just copy out the basic procedure provided in the question. There were a number of candidates who spent time repeating how they would make up their copper(II) sulfate 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 catalase and copper(II) sulfate solutions rather than just stating they would standardise these, which was excellent. Candidates needed to use the term volume, rather than amount, to gain credit here. It was also common to see a method being provided for maintaining a constant temperature which meant that many candidates gained credit.

Many responses mentioned replicating each concentration a suitable number of times, but this was sometimes linked to calculating an average. It is desirable to use the term 'mean' in scientific work.

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Many candidates were able to successfully identify a suitable hazard, its associated risk and the precautions they should take to minimise that risk.

Candidates needed to read through their completed method to ensure that they had set it out in a logical way and that it was detailed enough for another person to follow. Stronger candidates were more likely to refer to details such as rinsing the apparatus between replicates with water or using fresh solutions for replicates.

(iii) Many candidates were able to correctly place copper(II) sulfate concentration on the *x*-axis and volume of oxygen on the *y*-axis. Candidates needed to include the terms concentration or volume when adding their labels in order to gain credit. The information provided in the question should be used when labelling axes. Only a few candidates missed units and therefore were not able to attain full credit. Most candidates were able to sketch a graph to show the expected result.

(c) (i) Many excellent responses were seen with clearly labelled lines drawn on the graph to show how the K_m value of catalase without copper(II) sulfate could be derived. These responses correctly placed and identified the V_{max} and $^1/_2 V_{max}$ lines in addition to the K_m line. Candidates should use a ruler when drawing lines on graphs and ensure that they add labels to graphs.

(ii) Many candidates included details explaining how a non-competitive inhibitor works. Although many of the explanations were biologically correct, this is not what candidates were asked for and therefore they did not gain credit for this. Candidates needed to use evidence from the graph provided to support the conclusion that copper(II) sulfate was a non-competitive inhibitor. Those candidates who correctly identified that the line plateaued below the V_{max} line or that the maximum rate of reaction was lower with this type of inhibitor gained credit. Reference to the maximum rate, rather than just the rate of reaction was needed in this case. The best responses also included detail about the K_m value remaining in a similar position.

Question 2

(a) (i) Many candidates were able to correctly suggest that in order to prevent self-fertilisation, the anthers needed to be removed or covered. Some candidates suggested that the stigma needed removing or covering, however, this method would prevent all types of fertilisation, not just self-fertilisation and did not gain credit.

(ii) There were many detailed suggestions outlining methods for transferring pollen grains from an anther to a stigma. These included using paint brushes, Q-tips, rubbing the anther on the stigma and many more suitable methods. Some candidates needed to develop their answer to include these details of how the pollen grains could be transferred. A few candidates suggested that the wind or insects could be used. These suggestions did not gain credit as they are not a reliable way of ensuring that the pollen grains would be successfully transferred to the stigma.

(b) Many candidates performed very well in this question, with many attaining full credit.

(c) (i) Many candidates were able to calculate the value of chi-squared correctly. The most common mistake was to incorrectly round the values or to present a mixture of decimal places for values.

(ii) The vast majority of candidates were able to correctly state that they would reject the null hypothesis and provided valid reasons why. Some candidates needed to expand on their answer by referring to there being a significant difference between the observed and expected values. The best answers integrated a suitable conclusion, with ideas about the genes being on the same chromosome or autosomally linked being the most commonly seen.

(d) Many responses correctly incorporated the information provided in **Fig. 2.2**. Other responses needed to develop more detailed answers by stating that in sensitive plants there was a decrease in the percentage of pollen grains which grew pollen tubes rather than just a decrease in pollen grains, as these two statements do not mean the same thing.

To gain additional credit, candidates needed to identify if the standard error bars overlapped or not and what that meant in terms of there being a significant difference. A few candidates correctly identified that if there was no overlap of standard error bars then this suggested that there *may be* a significant difference. Those candidates who stated this meant that there *was* a significant

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difference did not gain credit, since this could only be concluded if further statistical analysis was carried out.

Some of the best responses referred to the fact that no statistical tests were carried out or that no information was provided about the concentration of copper ions in the investigation. When asked to justify a conclusion made by scientists, candidates should look critically at the procedures the scientists followed and evaluate if sufficient information is provided to make such claims.

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Key messages

Candidates are advised to read through all of the questions on the paper before starting to write so that their answers can be carefully structured to meet the specific requirements of each question.

General comments

Although only a small cohort sat this paper, there was a wide range of responses. There were some very good responses showing a good grasp of the material.

In general, the material on the chi-squared test was well handled and showed a good understanding.

Comments on specific questions

Question 1

The common theme in this question was based around inhibitors. In the first part, the candidates were asked to comment on aspects of the extraction of an enzyme (catechol oxidase) from banana tissue, and to design an experimental method to assess the effect of an inhibitor on the initial rate of the reaction catalysed by this enzyme. This was followed by a section testing their understanding of the types of enzyme inhibition. The final part of **Question 1** moved into a different aspect of biological inhibition involving control of hypertension.

(a) Candidates were told how some students had extracted catechol oxidase from bananas and were asked to suggest reasons for two parts of the process used – firstly, grinding with sand. Good responses clearly expressed the idea of breaking open the cells to release the enzyme. Less clear responses gave terms such as 'to extract the enzyme', which did not answer the question of how it helped in the extraction. There were also several answers which did not gain credit which referred to turning the banana into a paste or 'mush'. The role of filtering through cloth was generally better understood and expressed in terms of the idea of removing large bits of banana debris or sand.

(b) (i) Most candidates were able to convey the idea that the colorimeter gave a quantitative measurement of the intensity or absorbance. This was expressed in many ways with 'more accurate' or 'more precise' or 'objective' being common creditworthy approaches. Some responses were too generalised such as it being 'hard to judge colour by eye' with no qualification regarding intensity.

(ii) This was usually well answered. The commonest error for the independent variable was to just write catechol/substrate rather than its concentration. In a few cases there was confusion between the substrate (catechol) and the enzyme (catechol oxidase), with the latter being given as the independent variable. For the dependent variable (absorbance), credit was allowed for the intensity of the brown colour. References to the rate of absorbance were not credited.

(c) (i) There was quite a range of responses to the planning exercise. The strongest responses were set out clearly with a logical sequence of steps that would achieve the aim of the investigation. The first stage was to make a sufficient number and range of substrate concentrations. There needed to be at least five concentrations and the range should not have started above 1% as that was the

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concentration of the stock solution of catechol provided. Units for the concentrations were important and as the stock solution was 1%, values given as mol dm^{-1} were not acceptable.

In this exercise, it was important to use the materials and information provided correctly. A few candidates confused the substrate and enzyme and diluted the catechol oxidase. Reference to standardised stated volumes of enzyme, substrate and inhibitor were creditworthy. For the enzyme and inhibitor, standardised concentrations were an alternative way to achieve credit. Banana extract was allowed as an alternative to enzyme solution. Most candidates realised that, as an enzyme reaction was involved, it was necessary to carry out the reaction in a named temperature-controlled environment such as a water-bath. Fewer used the information provided and suggested a method for keeping the enzyme cool prior to the reaction. It is good practice to bring the enzyme and substrate to temperature and this gained credit provided it was clear that such equilibration occurred before mixing.

This investigation was to measure the initial rate of reaction and thus it needed to be clear that the absorbance should be read no later than 2 minutes after the reactants were mixed. There were many good answers making this point. Some candidates were confused and thought they were expected to follow the course of a reaction and thus suggested taking readings at a series of time intervals until something like an end-point was reached or the colour changed. This was not appropriate. Replicating the experiment was often well-covered and the correct use of the term 'mean' rather than 'average' is increasingly commonly seen. There were a number of inappropriate suggestions for controls such as with no enzyme or boiled enzyme. If the aim of the investigation is to be achieved, it is valid to repeat the whole series of catechol concentrations in the absence of inhibitor **Y** (in effect the experiment in **Question 1(b)**) in order to compare the initial rate with and without inhibitor **Y**.

Candidates should structure their risk assessment on the basis of identifying a precise hazard, a risk associated with that hazard and a linked precaution. Just stating low or medium risk unqualified is not enough to gain credit. Thus, as an example, the enzyme may be a hazard with the risk of an allergic reaction and the precaution would be suitable protective clothing such as masks or gloves. In this example, considering just 'the solutions' or 'the chemicals' was not enough. Something specific to the investigation needed to be identified.

(ii) The great majority of curves were correctly drawn to the right of the original and many plateaued appropriately. Some drew a curve suitable for a competitive inhibitor which allowed access to only limited credit. Curves that very closely followed the original curve throughout or started well along the *x*-axis gained no credit.

(iii) V_{max} was correctly identified on the *y*-axis by a large majority. K_m was identified correctly less often. K_m must be shown on the *x*-axis (not on the *y*-axis which would indicate $^1/_2\, V_{max}$ or as a dot on the actual curve). Some responses incorrectly labelled it on the *x*-axis by wrongly working out $^1/_2\, V_{max}$.

(iv) The question asked that the candidate use their graph to describe the effect of the inhibitor on the K_m. If the curve had been sketched correctly in **Question 1(c)(ii)** for a non-competitive inhibitor, then the value for the K_m would not change.

(d) Data on aspects of hypertension control were provided and the candidates were asked to discuss the conclusion that a combination of the two drugs should be used to lower blood pressure with reference to the data provided. A complete answer to this question required an evaluation on how far the conclusion can be justified. The strongest answers not only pointed out that the combination showed the greatest reduction, but also were able to indicate that there were a range of other things that needed to be known to be sure this was a valid conclusion. These included, amongst others credited, evidence from statistical tests to back up the conclusion, data on long term effects and possible side effects and evidence on the relative sizes of the four groups. Not all candidates appreciated that evaluation required this sort of approach and limited their answers to lengthy descriptions of the data which simply reiterated their original statement on reduction of blood pressure. Evaluation is a higher-level skill that candidates should improve with practice in preparation for this examination.

Question 2

This question tested candidates' understanding of the use of the chi-squared test in the analysis of genetics data. It was important that the information at the start of the question was carefully read and understood for

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responses to be successful. Many candidates realised this and followed a clear path through the steps required to answer each section. Less successful candidates became confused at an early stage.

(a) (i) Many candidates were able to gain credit here by the idea that the chi-squared test allowed the observed and expected data to be compared to see if there was a significant difference. Some responses mistakenly suggested that the test was used because there was a difference and another fairly common response which did not gain credit was to suggest it was to test if there was a correlation between the expected and observed data.

(ii) The majority of candidates gave a clear null hypothesis stating that there was no difference between the observed and expected results. A few were confused by this and gave the alternative hypothesis and did not gain credit.

(iii) Many candidates gained credit for the column headed **E** but some thought a 1:1 ratio was expected and gave 16 for all four rows. Others just put down 9:3:3:1 rather than the ratio as applied to the sample size of 64. Many had worked out the final column correctly and expressed each value to the same number of significant figures. Credit was lost for variable numbers of significant figures or incorrect rounding.

(iv) This was generally well answered with candidates quoting that $n - 1$ in this case gives $4 - 1 = 3$ degrees of freedom and that in biological data analysis the probability value of $p = 0.05$ is used.

(v) Good answers clearly stated that the null hypothesis was rejected as the calculated value was higher than the critical value of 7.82. This meant that there was a significant difference between the data. The conclusion from this regarding the inheritance of these genes is that they are linked/found on the same chromosome. Some candidates suggested that the calculated value being higher than the critical value meant that the null hypothesis was accepted which allowed only limited credit as long as the next steps were logically followed.

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