

Principal examiner reports for teachers

Principal examiner reports for teachers summarise what candidates did well and what candidates needed to improve for this examination series only.

This report is to be used in conjunction with the question paper and mark scheme.

For guidance on teaching and learning we provide resources for many of our syllabuses.

Resource	Where to find it
Grade descriptions – Grade descriptions describe the level of performance typically demonstrated by candidates achieving the different grades awarded for a qualification.	School support hub Select: Subject > Resource finder > Syllabus and specimen materials
Schemes of work – Schemes of work are designed to support you in your teaching and lesson planning.	School support hub Select: Subject > Resource finder > Teaching and learning
Lesson planning – Guidance on how to plan a lesson.	Lesson planning
Resource plus – There may be additional resources such as teaching packs containing lesson plans, resources and worksheets and videos for aspects of your syllabus.	School support hub Select: Subject > Resource finder > Teaching and learning
Teaching tools	Teaching Tools
Exemplar candidate responses	School support hub Select: Subject > Resource finder > Teaching and learning
Learner guide – A guide for students to help them understand what the course involves.	School support hub Select: Subject > Resource finder > Teaching and learning
Community forums – Do you have a question or something to share? Our online forums are great way to keep up to date with your subject and the global Cambridge community.	Community forum on the school support hub
Access to scripts for this series.	Access to scripts service
Results analysis is available for some syllabuses.	Results analysis
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BIOLOGY

Paper 9700/11
Multiple choice

Key messages

Candidates performed well on **Questions 1, 7, 8, 10, 15, 17, 18, 19, 23 and 36.**

Candidates performed less well on **Questions 12, 13, 20, 25, 27, 30, 34, 35, 38 and 41.**

There was no clear pattern in terms of which topics were challenging, but a few of the questions where candidates performed less well required the correct identification of structures on photomicrographs and diagrams or the interpretation of graphical data.

Comments on specific questions

Question 12

- Option **C** was a common incorrect answer.
- The graph showed that there was a decreased in thermal stability at lower temperatures when glycine was replaced by valine or serine. All three of the listed explanations could be possible reasons for these results.

Question 13

- Option **A** was a common incorrect answer.
- Absorbance would only be measured at one wavelength to follow the progress of a starch-amylase reaction. This means that step 3 is incorrect.

Question 20

- Options **B** and **C** were common incorrect answers.
- Option **B** can be excluded because centrioles are not present in typical plant cells.
- Option **C** can be excluded because DNA replication occurs in S phase, after G₁ phase, and there are no sister chromatids at that point.

Question 25

- Option **B** was a common incorrect answer.
- Most candidates knew that the nucleus is the location of transcription, although some confused the transcribed strand of the DNA with the primary transcript.

Question 27

- Option **B** was a common incorrect answer.
- Cell T in the photomicrograph is a phloem sieve tube element. The end walls are a useful feature for confirming its identification.
- Candidates who opted for B are likely to have thought that T was a xylem vessel.

Question 30

- Option **C** was a common incorrect answer.
- Candidates who opted for **C**, rather than the correct option **D**, had correctly recognised that the diagram showed a closed system with a heart but had not realised that the blood travelled through the pump twice in one complete circuit. This meant that the diagram also represented a double circulatory system.

Question 34

- Option **B** and option **D** were common incorrect answers.
- Option **B** is incorrect because the electric impulses pass between nodes of conductive tissue, not muscles.
- Option **D** is incorrect because semilunar valves close after ventricular systole, whereas the question asked for an event that occurred immediately after atrial systole.

Question 35

- Option **A** was a common incorrect answer.
- Option **A** is correct because tissue Y is smooth muscle.
- Candidates who opted for **A** are likely to have incorrectly identified tissue Y as cartilage.

Question 38

- Option **A** was a common incorrect answer.
- Option **A** is incorrect because it is the bacterial cell walls, and not their membranes, that are composed of peptidoglycan.

Question 40

- Option **D** was a common incorrect answer.
- Option **D** is incorrect because, although some vaccines do contain the target pathogen, this is not essential. Many vaccines contain only a single antigen.
- Option **C** is correct because if antigen X is used as a vaccine, it must stimulate an immune response.

BIOLOGY

Paper 9700/12 Multiple Choice
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Key messages

Candidates performed well on **Questions 3, 5, 17, 23, 28, 33, 36, 37, 39 and 40.**

Candidates performed less well on **Questions 4, 7, 8, 10, 13, 15, 22, 25, 34 and 35.**

The questions on biochemistry were found to be more challenging, whereas questions on infectious diseases and immunity were well answered. A few applied questions, particularly those involving cancer, were among those where candidates performed less well.

Comments on specific questions

Question 4

- Options **A** and **B** were common incorrect answers.
- The mitochondria and nucleus will be the first cell structures to contain the radioactively labelled nucleotides because they contain DNA.

Question 7

- Option **C** was a common incorrect answer.
- Because maltose is a reducing sugar, it will give a positive test result for the reducing sugar test, but not the non-reducing sugar test.

Question 8

- Option **C** was a common incorrect answer.
- Candidates who opted for the correct option **D** had remembered that a water molecule is removed each time a glycosidic bond forms. This means that there are two fewer hydrogen atoms and one less oxygen atom in the repeating monomer of starch than in the general formula for a hexose.

Question 10

- Options **A** and **C** were common incorrect answers.
- Those candidates who opted for **A** had not remembered that there will be one fewer water molecule than the total number of hydrolysis reactions in the formation of glucose from X and maltose for Y.
- Those candidates who opted for C had made a similar miscalculation to those who chose A, but had also thought that there were half the number of hydrolysis reactions in both X and Y.

Question 13

- Option **D** was a common incorrect answer.
- Almost all candidates had correctly excluded statement 1. Haemoglobin is a soluble globular protein and so many hydrophilic R-groups will be found on the surface of the molecule.
- Almost all candidates had also correctly included statement 3. There is a conformational change in the structure of haemoglobin when oxygen binds to it.
- Fewer candidates knew that statement 2 was also correct. The hydrogen bonds with the amino and carboxyl groups of different amino acids are required to form the secondary structure and, as such, help to stabilise the tertiary structure.

Question 15

- Option **D** was a common incorrect answer.
- Most candidates knew that statements 2 and 3 could explain the decrease in the rate of reaction.
- Those candidates who opted for **A** also knew that statement 1 was correct. A mutation in the gene coding for an enzyme could result in a change to its shape such that it has an increased affinity to an inhibitor. This would then also result in a decrease in the rate of the enzyme-catalysed reaction.

Question 22

- Option **B** was a common incorrect answer.
- Spindle fibre formation begins during prophase, and so this is the first stage that will be affected by the chemicals.

Question 25

- Option **A** was a common incorrect answer.
- Option **A** is incorrect because ligase is only involved in the formation of phosphodiester bonds between fragments of DNA, and not between free nucleotides and a DNA fragment.

Question 34

- Option **D** was a common incorrect answer.
- Option **D** is incorrect because, whereas the atria (chambers Y and Z) will contract together, the left ventricle (W) will not contract before the right ventricle (X). The ventricles will contract together.

Question 35

- Option **A** was a common incorrect answer.
- Option **B** is correct because the oxygen molecule will need to travel through the phospholipid bilayer of the squamous epithelial cell, in and out of the endothelium of the capillary, and into the red blood cell to form oxyhaemoglobin.

BIOLOGY

Paper 9700/13 Multiple Choice
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Key messages

Candidates performed well on **Questions 11, 13, 14, 16, 23, 26, 27, 28, 34 and 38**.

Candidates performed less well on **Questions 4, 5, 6, 10, 12, 20, 21, 22, 29 and 40**.

Challenging topics included cell structure and biological molecules. Candidates also performed less well on questions from other topics that required particularly careful reading of the questions and options, or application of knowledge.

Comments on specific questions

Question 4

- Option **D** was a common incorrect answer.
- Option **A** is correct because the cell walls of plant cells limit the volume of water that can enter by osmosis. This makes the need for contractile vacuoles unnecessary.
- Although plant roots are involved in water uptake in most plants, this does not preclude the need for cells to regulate their size.

Question 5

- Option **B** was a common incorrect answer.
- Candidates who opted for **B** made the correct choice for cytoplasmic ribosomes and plasmodesmata but incorrectly thought that microtubules are not present in plant cells.
- Option **B** contains familiar terms for the secondary structure of proteins, such as β -pleated sheets and α -helices. However, β -pleated sheets are not coils of amino acids. Furthermore, the polypeptides in a quaternary structure do not necessarily need to be different.

Question 6

- Option **D** was a common incorrect answer.
- Circular, double-stranded DNA is found in the mitochondria of eukaryotes. This makes it a common feature of both prokaryotic and eukaryotic cells.
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Question 10

- Options **A** and **B** were common incorrect answers.
- Almost all candidates knew that the large number of hydrogen bonds helps to stabilise collagen (statement 2).
- There are no alpha helices or beta-pleated sheets in collagen. This means that statement 1 is incorrect.
- There are repeated amino acid sequences, and these are involved in determining the tertiary structure (statement 3).

Question 12

- Option **B** was a common incorrect answer.
- Interaction 2 is a disulfide bond, but since disulfide bonds are examples of covalent bonds, both terms are correct.

- There is a hydrophobic interaction shown between the two amino acids in interaction 1. This means row **C** is the correct option.

Question 20

- Option **C** was a common incorrect answer.
- The growth of individual cells does occur, but this does not involve the formation of new cells.
- Although tissues can be repaired by mitosis, an individual cell cannot.

Question 21

- Options **B** and **C** were common incorrect answers.
- The question asks about the events that occur to a cell that has just completed telophase.
- Option **B** is incorrect because DNA replication will occur before the nuclei divide.
- Option **C** is incorrect because the next event after telophase is cytokinesis.

Question 22

- Options **A** and **B** were common incorrect answers.
- The centrioles move to the poles in prophase, and so this is the stage of mitosis that a cell will reach but not complete.

Question 29

- Options **A** and **C** were common incorrect answers.
- Statement 2 is incorrect because there are no cell surface membranes in xylem vessels. Water transport in the xylem is by mass flow.
- Statement 3 is incorrect because water movement through cell surface membranes is part of the symplast pathway.

Question 40

- Option **D** was a common incorrect answer.
- It is not possible to pinpoint the day when the second exposure to the antigen occurred.
- Memory cells will have been produced by 20 days because there has been an increase in antibodies by this time.

BIOLOGY

Paper 9700/14 Multiple Choice
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Key messages

Candidates performed well on **Questions 1, 4, 13, 16, 18, 22, 26, 27, 34 and 40.**

Candidates performed less well on **Questions 6, 7, 10, 11, 12, 15, 21, 23, 28 and 36.**

There was no clear pattern in terms of which topics were challenging, but many of the questions where candidates performed less well required particularly careful reading of both the question and the options.

Comments on specific questions

Question 6

- Option **C** was a common incorrect answer.
- Statement 3 is incorrect because free ribosomes are also found in eukaryotic cells.

Question 7

- Option **D** was a common incorrect answer.
- Statement 1 is correct because if the solution had contained starch only, the positive result for the Biuret test could have occurred because the enzymes added to the solution are proteins. In addition, amylase would have digested the starch, giving a positive Benedict's test.
- Statement 4 is correct because there is no enzyme in the mixture to digest the protein. These proteins, and the enzymes would have contributed to the positive Biuret test. The reducing sugars formed from the starch digestion would have given the positive Benedict's test.

Question 10

- Although slightly more candidates selected the correct option, **D**, all options were popular.
- Candidates who opted for **D** knew that saturated phospholipids would have two ester bonds and that there is a double bond between a carbon and oxygen molecule in each bond, with no double bonds in the saturated fatty acid chains.
- From the formula of the additional group candidates could deduce that it contained no double bonds.

Question 11

- The correct option **B** was selected by slightly more candidates with similar numbers of candidates selecting the other options.
- Collagen and haemoglobin are both proteins. Since there is at least one double bond in each amino acid, there will be many more than six double bonds in each of these molecules.
- Monounsaturated triglycerides will have a minimum of four double bonds (one in the ester bond of each of the three fatty acids, and one in the chain of one of the fatty acids). This is less than six.

Question 12

- All options were popular.
- Denaturation involves the loss of the three-dimensional structure of a protein, but the primary structure remains intact. This means that the first event in the list is not correct.
- The other three events describe aspects of denaturation that would occur at extreme pHs.

Question 15

- Option **D** was a common incorrect answer.
- Those candidates who opted for **D**, rather than the correct option, **C**, had misidentified hydrogen peroxide as a product rather than a reactant.

Question 21

- The correct option **B** was selected by slightly more candidates with similar numbers of candidates selecting the other options.
- Those candidates who opted for an incorrect sequence of events were not aware that uncontrolled cell division would mean a decrease in interphase and that mitosis would start after the G₂ phase.

Question 23

- Option **A** was a common incorrect answer.
- Option **A** is incorrect because there are no phosphodiester bonds in ATP.

Question 28

- Option **A** was a common incorrect answer.
- Candidates knew that there was no lignin in the walls of phloem sieve tube elements but did not know that the elements would have a water potential that is less negative than that of the source before loading.

Question 36

- Option **D** was a common incorrect answer.
- All three factors contribute to the spread of cholera. Flies can land on a contaminated surface and quickly transfer the pathogen from one place to another.

BIOLOGY

Paper 9700/21
AS Level Structured Questions

Key messages

What candidates did well

- Many candidates used the information in Figure 5.1 to give thorough explanations of the movement of sucrose from a mesophyll cell to a phloem sieve tube element. Many included the symplast pathway and the apoplast pathway in their answers.
- There were many good descriptions of the procedure to determine the actual length of the organelle, labelled **A**, the mitochondrion, shown in Figure 1.1.
- Candidates showed good knowledge of the stages of protein synthesis, as described in answers to **Question 1 (b)** and **Question 3 (a) (iii)**.

What candidates needed to improve

- Candidates need to know how β -pleated sheets are depicted in ribbon diagrams of proteins. Many candidates stated that the SWEET protein shown in Figure 5.2 had these secondary structures. Few candidates knew that the parts that connect the α helices shown in Figure 5.2 are known as random coils or regions without an organised secondary structure.
- In answering **Question 2 (a) (ii)**, candidates gave answers that suggested they did not realise that vaccines are used to stop a pathogen spreading through the body once it has entered. Many candidates wrote about the role of the immune system and the effect of HIV on the body after an infection has spread.
- Candidates need to distinguish between the manufacture of monoclonal antibodies as depicted in the flow chart in Figure 6.1 and the production of antibodies as part of an immune response in the bodies of humans and other mammals. Candidates often implied in answers to **Question 6 (d)** that hybridoma cells can produce humanised antibodies in the body that will not stimulate an immune response and will result in memory cells that remain for a long time.
- Candidates were not very secure in writing about the relationship between the structure of muscular arteries and their functions in **Question 4 (a) (ii)**. They often implied that smooth muscle contracts to push blood, as if blood flow were peristaltic.
- Candidates should check their answers by reading them carefully. In **Question 3 (a) (i)**, for example, some candidates wrote DNA when they clearly meant to write RNA.

Comments on specific questions

Question 1

(a) (i) Comprehensive responses

- Many candidates gave two steps that are taken to determine the actual length of structure **A** in the transmission electron micrograph (TEM) in Figure 1.1. Most stated that the length on the TEM would be measured in millimetres or centimetres, with the result divided by the magnification.
- Candidates often gave the correct way to convert the result to micrometres.

Limited responses

- Some candidates simply gave the formula for calculating actual size from an electron micrograph.
- A few described how to measure the organelle with a light microscope using an eyepiece graticule.

(ii) Comprehensive responses

- Some candidates gave examples of cell structures in a pancreatic cell that would be visible in a light microscope, such as the nucleus, nucleolus, cell surface membrane and Golgi body.
- Although the structure of the cell surface membrane is not visible because its width is below the resolution of the light microscope, this was accepted because of the clear difference in appearance between the cytoplasm and the surrounding extracellular material. This difference exists because of the cell surface membrane.

Limited responses

- Many candidates gave rough or smooth endoplasmic reticulum. Neither of these is visible when using a light microscope. Some candidates included mitochondria, which was not one of the structures required. Some answers included only one structure instead of the two required.
- Many candidates omitted the word 'surface' from 'cell surface membrane'.

(iii) Comprehensive responses

- Many candidates explained that some cell structures are not visible in a light microscope because of its lower resolution compared with the TEM. They either stated that structures less than 200 nm are not visible in a light microscope or, less often, that these structures are less than half the wavelength of light.

Limited responses

- Some candidates confused resolution with magnification, stating that the TEM gives a much higher magnification than the light microscope. Candidates should appreciate that organelles that are not visible in a light microscope are not visible when a photomicrograph is magnified thousands of times. Candidates should recognise that low resolution means that a light microscope cannot distinguish between two points that are close together.
- Many candidates referred to light microscopes having a lower ability to distinguish between structures or simply said that small organelles could not be seen under a light microscope. These candidates rarely referred to the resolution of the light microscope (200 nm).

(b) Comprehensive responses

- Most candidates wrote a good description outlining the roles of ribosomes, rough endoplasmic reticulum, Golgi body and Golgi or secretory vesicles in the synthesis and release of enzymes. These answers usually referred to more structures than the minimum required.
- Some candidates included information about transport vesicles, which transfer proteins produced by the rough endoplasmic reticulum to a Golgi body. Candidates occasionally called these shuttle vesicles.

Limited responses

- Some candidates included the role of the nucleus, although they often omitted stating that it is the genes in the nucleus that code for the pancreatic enzymes that are transcribed.
- Many candidates stated that proteins are synthesised by the smooth endoplasmic reticulum.
- Many candidates wrote about the role of lysosomes, although these are not involved in the release of pancreatic enzymes from the cell.

Question 2

(a) (i) Comprehensive responses

- Many candidates stated that infectious diseases are caused by pathogens and are transmissible.
- Descriptions of transmission as the transfer of a pathogen from an infected person (or host) to an uninfected person (or host) were accepted.

Limited responses

- Many candidates did not state that the diseases are caused by pathogens.
- Many stated that the diseases are transferred from person to person without indicating which person was infected and which was not.

(ii) Comprehensive responses

- Some candidates explained that the high mutation rate of HIV leads to frequent changes in the antigens on the surface of the virus. This is a challenge for those attempting to develop a vaccine to protect against HIV, as vaccines would have to contain a variety of antigens and/or the vaccine would need updating very frequently.
- Some candidates used their knowledge of the immune response to suggest that any immunity gained from a vaccine would not last long, as the virus constantly changes its antigens. Some also suggested that the different strains of HIV pose a similar challenge.

Limited responses

- The majority of candidates only referred to the virus mutating rather than mutating frequently or having a high rate of mutation. Quite a few candidates thought that HIV, being a virus, does not have any antigens and therefore vaccines would not work.
- Many candidates misunderstood the question and tried to explain how HIV would destroy lymphocytes in the body of a person with the virus, meaning that they would not be able to produce antibodies.

(b)(i) Comprehensive responses]

- Many candidates calculated the percentage decrease as 85 per cent.

Limited responses

- Many candidates chose a figure taken from the graph rather than the UN target of 0.18 million by 2030.
- The most common errors were 87.5 per cent and 15 per cent. Many other answers were given.

(ii) Comprehensive responses

- Many candidates stated that blood donations can be screened for the presence of HIV or can be treated to destroy any viruses.
- Others stated that people who are HIV-positive should not be allowed to donate blood.
- Some stated that pregnant women who are HIV-positive can be treated with antiretroviral drugs (ART) and/or advised avoiding breastfeeding their babies and to use formula milk instead.

Limited responses

- Many candidates stated that using sterile needles during blood transfusion reduces the risk of infection without recognising that this would not be effective if the blood came from an HIV-positive donor.
- Many gave more than one reason for each row, which, in some cases, resulted in contradictory answers.
- Some candidates suggested that **HIV-positive** mothers should not have children.

Question 3

(a)(i) Comprehensive responses

- Some candidates identified the two nitrogenous bases in row 1 as purines and named them as adenine and guanine. They also identified the bases in row 2 as pyrimidines and named them as thymine, cytosine and uracil. They stated that DNA and RNA contain both purines and pyrimidines, and that DNA has thymine while RNA has uracil.
- Few candidates explained that complementary base pairing in DNA would not be possible with five bases and that production of RNA by transcription would also not be possible, as the only pairings are A-T, C-G and A-U.

Limited responses

- Many candidates omitted stating that the bases in row 1 are purines and the bases in row 2 are pyrimidines, even if they named them all correctly.
- Some candidates did not spell the names of the bases correctly.

(ii) Comprehensive responses

- Some candidates stated that nitrogenous bases gain a pentose sugar and a phosphate group to become a nucleotide.

- A few went further, stating that a nucleotide becomes activated by the addition of two further phosphate groups.

Limited responses

- Many candidates did not realise that nitrogenous bases on their own cannot become part of a nucleic acid, so the addition of a base to a strand of DNA and the formation of hydrogen bonds between bases do not happen. These candidates did not state clearly that nucleotides are used to synthesise nucleic acids and that base pairing occurs between nucleotides.
- Some candidates gave answers that explained complementary base pairing in detail.
- Some candidates misunderstood the question and explained how DNA or nucleic acids are formed rather than describing the formation or composition of a nucleotide.
- Many stated that bases are joined by phosphodiester bonds.

(iii) Comprehensive responses

- Few candidates gave a comprehensive description of the features of the genetic code. Many stated that three bases, triplets of bases or codons code for amino acids, and the remainder of their answers was a description of the events that occur in translation.

Limited responses

- Some candidates described the role of stop codons. Very few included the role of the start codon AUG.
- Many candidates misunderstood the question and referred to introns and exons and/or described the process of translation, often in great detail.
- Very few candidates described the sequence of codons determining the primary structure of polypeptides. Instead, they repeated the stem of the question and referred to the sequence of codons determining the sequence of amino acids in the polypeptide.

(b)(i) Comprehensive responses

- Some candidates gave transcription, replication and coiling, decondensing or supercoiling as the three processes involving DNA in the nucleus during the three stages of the cell cycle shown in Figure 3.2.

Limited responses

- Many candidates did not identify events that involved DNA in the nucleus. Instead, they named the stages of the cell cycle or described processes that do not involve nuclear DNA, such as translation or the synthesis of organelles, which were often given as answers for stage 1.
- Some used the phrase 'DNA duplication' instead of the correct term, DNA replication.

(ii) Comprehensive responses

- Some candidates gave detailed descriptions of cytokinesis. They stated that a cleavage furrow appears as a result of constriction of the cytoplasm caused by the ring of microtubules underneath the cell surface membrane at the equator of the cell. They also stated that, as this ring 'tightens', membrane fusion occurs to give two daughter cells.

Limited responses

- Many descriptions of cleavage began with accounts of events involving chromosomes, spindle fibres and nuclear membranes during telophase, with little information about what happens next as the cell divides.
- Many focused on the production of two nuclei rather than the distribution of organelles between two daughter cells.
- A minority of candidates included information about cytokinesis in plant cells, which was not relevant to the question
- Cell membranes were often described as 'attaching' or 'joining' rather than fusing to complete cytokinesis.

(iii) Comprehensive responses

- Most candidates stated that DNA polymerase and/or DNA ligase catalysed the formation of phosphodiester bonds.
- Additional information was usually given, such as: bond formation occurs during the S phase of the cell cycle when DNA is being replicated; the enzyme forms the bonds between activated

or free nucleotides and the growing strand during replication; and the nucleotides are added in the 5' to 3' direction.

- Almost all candidates stated that DNA ligase forms bonds between the Okazaki fragments, with some adding the information that this happens on the lagging strand during replication.
- A small number of candidates stated that error checking is another role of DNA polymerase.

Limited responses

- The statements about DNA ligase were generally more accurate than those about DNA polymerase. Candidates who attempted to write about the role of DNA polymerase in replication rarely gave accurate information. Examples were 'the addition of nucleotides to the template strand', 'the formation of bonds between free nucleotides', and 'adds free nucleotides along the template strand'. In the latter case, there is no mention of the elongating strand or the new strand.
- Many candidates gave less precise answers; for example, some described bonds being formed in the Okazaki fragments rather than between them.
- Some candidates stated that DNA ligase splices introns back together during or after transcription.
- Some candidates wrote about RNA polymerase, even though the question specifically asks about DNA polymerase.

Question 4

(a) (i) Comprehensive responses

- Only a small proportion of candidates correctly identified the main component of each of the regions of the muscular artery shown in Figure 4.2.
- Region P clearly showed the internal elastic lamina of the tunica interna, bordering the tunica media. Although some stated this as the main component, many identified P as the endothelium. The endothelium was accepted as an alternative because it is visible and has a major role to play in the transport of blood.
- Many candidates identified the main component of region Q as smooth muscle, and fewer identified the main component of region R as collagen fibres or simply as collagen.

Limited responses

- Some candidates gave the names of the three regions of the muscular artery instead of identifying the main component. Smooth muscle (Q) was often identified simply as muscle rather than smooth muscle. The main component of region Q was often given as elastic fibres or elastin rather than collagen. Some candidates gave cartilage as the main component of region R.
- The endothelium was often identified incorrectly as squamous epithelium. Candidates should know from their study of the structure of arteries, veins and capillaries that blood vessels are lined by endothelial cells, not epithelial cells, although endothelial cells are squamous in appearance.
- Some candidates gave more than one component for one or all of the regions of the artery. The question asked for the main component, not components.

(ii) Comprehensive responses

- Some candidates gave detailed explanations of the roles of the endothelium, elastic fibres, smooth muscle and collagen. The endothelium was stated to allow smooth blood flow and/or reduce friction. Elastic fibres were said to stretch to allow the artery to expand following the contraction of the heart and recoil to maintain blood flow and blood pressure. Smooth muscle in muscular arteries contracts to reduce blood flow to capillaries and relaxes to increase blood flow to capillaries. This tissue also contracts continuously to maintain muscle tone and blood flow. Collagen provides the strength needed to maintain the structure of the artery without bursting.
- Candidates often did not differentiate between smooth muscle contracting and relaxing and instead wrote more general statements about vasoconstriction and vasodilation.

Limited responses

- Many explanations did not give the expected detail about the elastic fibres and smooth muscle.

- The question asked for an explanation of the relationship between structure and function. Candidates often gave general descriptions rather than explaining how the structures were related to their functions.

(iii) Comprehensive responses

- Many candidates stated that the aorta is wider or larger than the muscular artery, with many stating that the lumen of the aorta is wider. Many also stated that the wall of the aorta is thicker.
- Some candidates described the composition of the wall of the aorta, comparing it with that of the muscular artery. They made clear that the aorta has a higher proportion of elastic fibres compared with smooth muscle.

Limited responses

- Many candidates simply stated that there is more elastic tissue in the wall of the aorta without comparing this with the quantity of smooth muscle. The aorta has a thicker wall, so it is to be expected that it contains more elastic fibres.
- Some candidates did not identify the aorta as the main artery of the body.
- Many candidates stated in (iii) and (ii) that arteries pump blood.
- Some candidates stated that the aorta has semilunar valves.

(b) Comprehensive responses

- Many of the drawings of a neutrophil and a lymphocyte were accurate. The nucleus of the neutrophil was drawn with lobes that were all interconnected, and lymphocytes had nuclei filling almost the whole cell.

Limited responses

- Some candidates drew nuclei without lobes, often having a U-shape. Circles linked by single lines were not accepted. Some lymphocytes were drawn with nuclei that were too small. Any nucleus that filled less than 75 per cent of the cell was not accepted.
- A few candidates added diagrammatic antigen receptors to the cell surface membrane of their lymphocytes. Receptor molecules are not visible in a light microscope.

(c) Comprehensive responses

- Most candidates gave ciliated epithelium, cilia, goblet cells or cartilage as the features shown by the bronchus.

Limited responses

- A few candidates gave other features that are not found in the wall of the bronchus, such as bone, epidermis and alveoli.
- Some did not give sufficient detail, for example, epidermal cells rather than ciliated epithelium.

Question 5

(a) Comprehensive responses

- Most candidates stated glucose and fructose as the two monosaccharides that are used to make sucrose. Some qualified their answers by referring to α -glucose and β -fructose.

Limited responses

- Incorrect answers included glucose and galactose, α -glucose and β -glucose, glucose and maltose, and glucose and hexose.

(b) Comprehensive responses

- Many candidates gave detailed explanations of the movement of sucrose from mesophyll cells to phloem sieve tubes. They stated that sucrose travels along the symplast pathway by diffusion and goes from cell to cell through the plasmodesmata. Many described the apoplast route from phloem parenchyma cells to companion cells and then explained how sucrose is moved from the cell walls to the cytoplasm of the companion cells against its concentration gradient. There were good descriptions of the active loading of sucrose using the concentration gradient for hydrogen ions. Many candidates gave the term secondary active transport to describe this movement.

Limited responses

- Some explanations referred to the mesophyll cells as the source and the phloem sieve tube element as the sink. Source is the correct usage. The sink is the destination of the sucrose after transport in the sieve tubes.
- Some candidates stated that sucrose travels between the cells in the symplast pathway via plasmodesmata without stating that this is by diffusion or describing the movement as down a concentration gradient. Instead, some candidates used the term 'passive movement', which includes osmosis and is incorrect in this context. Some candidates stated that sucrose moves by osmosis.
- Some candidates incorrectly identified the location of the proton pumps and cotransporter proteins, stating that they are in the cell surface membranes of mesophyll cells or phloem parenchyma cells.
- Some candidates stated that a Casparian strip made of suberin blocks the apoplast pathway for sucrose between mesophyll and phloem parenchyma cells. There is no Casparian strip in leaves.

(c) (i) Comprehensive responses

- Many candidates stated that the SWEET protein is a transmembrane protein or used an alternative term such as integral, intrinsic, carrier or channel protein. Most also stated that the protein is composed of α -helices, with fewer stating that there are seven.
- Some stated that the protein is globular and also has random coils that connect the α -helices.

Limited responses

- Some candidates thought that each α -helix was a polypeptide and described the protein as having quaternary structure. This was not the case and was not credited.
- Many stated that β -pleated sheets are also visible when they are not. They may have interpreted the random coils as β -pleated sheets.
- Many candidates described the phospholipid bilayer structure and/or the bonds that hold proteins in shape. Neither description was relevant to the question.

(ii) Comprehensive responses

- Many candidates stated that sucrose is a polar molecule that cannot pass through the hydrophobic core of the phospholipid bilayer or is repelled by the fatty acid tails of the phospholipids. Many also stated that the centre of the SWEET protein is hydrophilic, allowing facilitated diffusion of sucrose.

Limited responses

- Some explanations referred to the SWEET protein as a carrier protein using energy to move sucrose across the membrane of phloem parenchyma cells. Figure 5.1 shows that movement out into the apoplast is passive, not active.
- Many candidates described sucrose as being large rather than stating that it was polar or hydrophilic. Some thought that the SWEET protein allowed sucrose to be actively transported across the membrane rather than move by facilitated diffusion.

Question 6

(a) Comprehensive responses

- Most candidates stated that plasma cells or B-lymphocytes are the cells collected from the spleen of small mammals during the process of making monoclonal antibodies (mAbs).

Limited responses

- Incorrect answers included lymphocytes without any qualification, white blood cells, memory cells, stem cells and cancer cells.

(b) Comprehensive responses

- Many candidates stated that myeloma cells are used in the production of mAbs because they can divide by mitosis and can continually divide, producing a large number of hybridoma cells once fused with plasma cells.
- Some explained that these cells have telomerase and are therefore able to live for a long time.

Limited responses

- Some explanations omitted the term mitosis and made no reference to myeloma cells being capable of dividing many times. Use of the term 'uncontrolled' was not credited.
- Few candidates stated that myeloma cells can be kept in culture.
- A common error was to state that myeloma cells replicate instead of stating that they divide by mitosis.

(c) Comprehensive responses

- Many candidates stated that the clones producing a suitable mAb to test for mpox can be identified by adding the whole virus or antigens from the virus to the culture medium. Any clones that produce mAbs able to bind to the virus or its antigens would be suitable for the diagnostic test strips.

Limited responses

- Candidates discussed how the mAb works and how to attach it to a test strip instead of suggesting a way to identify the clones. Many also stated that fluorescent tags can be added to the antibodies without mentioning mpox or its antigens in their answers.

(d) Comprehensive responses

- Some candidates stated that the mAbs produced by the genetically modified small mammals would not be recognised as foreign and would not be destroyed by the immune system. This means that the mAbs can be used for long-term treatments. Some also stated that the mAbs would not need to be humanised after production.

Limited responses

- Some candidates explained the advantages of using small mammals to produce these mAbs rather than the advantages of using the mAbs produced by small mammals that had the human gene inserted into their genome.

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Paper 9700/22
AS Level Structured Questions

Key messages

What candidates did well

- Many of the candidates who had correctly identified cartilage for **Question 2(a)(i)** continued in **Question 2(a)(ii)** to give a detailed account of the features and role of cartilage in the trachea and bronchi.
- The majority of candidates had a very good grasp of the overall structure of the heart and the associated blood vessels of the double circulatory system of mammals. Many did very well answering **Question 5(a)**.
- Candidates had a good outline knowledge of the steps involved in the production of monoclonal antibody by the hybridoma method. Most were able to organise the steps stated in Figure 4.1 in **Question 4(b)** to obtain the correct sequence for the process.

What candidates needed to improve

- Candidates should be familiar with naming a type of tissue and naming the type of cell or cells forming that tissue. **Question 2(e)(i)** asked for a type of cell, so it was not appropriate to state endothelium, as this is the tissue. Although they have similar structure-to-function features, squamous epithelial cells of the alveolar wall are not the same as endothelial cells in the capillary wall.
- **Question 2(f)(ii)** highlighted that some candidates needed to be more familiar with the difference between collagen polypeptides, collagen molecules, collagen fibrils and collagen fibres.
- Candidates should avoid using the term 'genetic code' when describing the nucleotide sequence or base sequence of a gene or of the entire genome of the organism. In **Question 4(c)(ii)**, it was not correct to state that the genetic code of gene *HPRT* had changed. It was also not sufficient to describe a change in the base sequence or nucleotide sequence of *HPRT* as a change in the gene sequence or a change in the DNA sequence.

Question 1

(a) Comprehensive responses

- Most could name an organelle present in a non-prokaryotic cell that is surrounded by a double membrane. Of these, the majority named either the nucleus or the mitochondrion. Many were able to spell the nucleus correctly, fewer used the correct singular term, mitochondrion.

Limited responses

- A proportion did not spell nucleus correctly and some incorrectly stated the nucleolus. A high proportion used the plural mitochondria instead of mitochondrion. Some responses stated an organelle bound by a single membrane.

(b)(i) Comprehensive responses

- Most knew that structure A was the capsid, and a smaller proportion gave the less scientific name, protein coat, which was acceptable. Some of those correctly stating cell wall for structure B also gave peptidoglycan or murein as an additional detail. This was not required, although it did confirm correct knowledge.

Limited responses

- A large number of candidates incorrectly stated cell membrane, or cell surface membrane, for structure B.

(ii) Comprehensive responses

- A correctly calculated value, given to the nearest whole number, was seen for many candidates.

Limited responses

- Some candidates did not notice, or forgot, the instruction to give their answer to the nearest whole number.
- Some candidates gave a whole number which was slightly out of the acceptable range. If they had measurements of line X-Y and of the T-phage length stated, this was accepted as an error, carried forward.
- Some candidates did not use the stated actual length of line X-Y of 0.9 μm to make an estimate of the actual length of the T-phage so that they could check if their calculated value was reasonable.

(c)

Comprehensive responses

- Most used knowledge of the principles of antibody-antigen binding and enzyme-substrate binding to realise that a T-phage can attach only to *Escherichia coli* cells because binding involves an element of specificity.
- The best responses used the information in Figure 1.1 to note that the T-phage tail fibres could be the point of attachment and made a sensible suggestion of a structure on *E. coli* to which attachment could occur.

Limited responses

- Some candidates mentioned only the T-phage or only the *E. coli* cell in their response.
- Some candidates switched to stating 'the enzyme' or 'the antibody' instead of stating the T-phage.
- Some thought that the T-phage could attach to *E. coli* because the bacterium did not possess a cell wall.

(d)(i)

Comprehensive responses

- The great majority named malaria as the disease least likely to be treated with bacteriophage therapy and most then gave a correct reason for this.

Limited responses

- Some named malaria and should have qualified this with an explanation.
- Some named tuberculosis or cholera, believing that the stated disease could only be treated with specific drugs, without justifying this idea.
- Some responses named one or more of the diseases and stated that they were caused by a virus.

(ii)

Comprehensive responses

- The most comprehensive answers suggested a variety of benefits so that a full response was assured.
- Many showed an understanding of how bacteriophage therapy could help alleviate the problem of antibiotic resistance and some of these also explained that by causing the death of the cell, there was little likelihood of resistance to bacteriophage therapy occurring.
- Some were clear in suggesting that the bacteriophage could not harm human host body cells.
- A small proportion noted that bacteriophage therapy would be enhanced by viral replication within host cells.

Limited responses

- Candidates who realised the specificity of the T-phage could have improved their response by stating that the therapy would be targeted only at the pathogen, because by stating that the T-phage only attacked bacterial cells they were also implying that beneficial bacterial cells could be affected.
- Some candidates concentrated only on one benefit of the therapy and should have thought of a greater number of suggestions.
- Some misread the question and suggested how the T-phage could destroy the bacterial cell rather than suggest the benefits of bacteriophage therapy.

Question 2

(a) (i) Comprehensive responses

- Many were able to name cartilage as the tissue containing chondrocytes and to spell it correctly.

Limited responses

- Not all variations of the spelling of cartilage were given the benefit of doubt as they were too far from the actual term.
- The most common incorrect answers were smooth muscle, elastic tissue and ciliated epithelium. It was notable that those stating ciliated epithelium as a tissue containing chondrocytes went on in **part (a)(ii)** to only name goblet cells and ciliated epithelial cells.

(ii) Comprehensive responses

- There were some very full accounts of the features of cartilage, and all the expected ideas were seen from some candidates.
- Responses that were well expressed frequently used shorter statements to describe the features clearly, for example separating structural from functional features and then separating the flexible nature of cartilage from its strength and ability to provide support.

Limited responses

- Some candidates focused only on the C-shaped cartilage rings in the trachea and/or the irregular plates of cartilage in the bronchi and could have improved further by considering the functional features.
- It was possible to be considered for an error, carried forward, for describing features for a tissue that was incorrectly named in **part (a)(i)**, if this tissue formed part of the trachea and bronchi, such as smooth muscle. Some who took this approach needed to give a more factually correct answer, for example stating the smooth muscle contracts and relaxes rather than expands and recoils.

(b) Comprehensive responses

- The most accurate responses reflected an understanding that telomere ends shorten each time DNA replicates and that continued mitosis would result in the loss of genes.
- The responses were clear that telomeres were part of the DNA molecule and did not contain genes.

Limited responses

- Candidates were imprecise in stating that telomeres prevent the loss of genetic material, rather than genes, and some gave contradictory details by then stating that telomeres shortened, which *is* a loss of genetic material.
- A number of candidates incorrectly described telomeres as non-coding genes.

(c) Comprehensive responses

- The question asked candidates to name the cell structures involved in the formation of the mitotic spindle. Many correctly stated centrioles. The centrosome in a non-dividing cell is a cell structure in which the pair of centrioles is located. Knowledge of the centrosome is not required for the 9700 syllabus. If stated, then this was accepted.

Limited responses

- Some candidates gave two cell structures and usually in these cases centrioles and microtubules were stated. As microtubules are involved in the spindle in plant cells, these responses were rejected.
- The most common incorrect responses seen were microtubules and ribosomes.

(d) Comprehensive responses

- The most concise answers described the chromosome at telophase, as instructed. The best of these knew that the chromosome could no longer be described as comprising two sister chromatids joined at the centromere and knew that it now consisted of a single DNA molecule complexed with histone proteins and with its own centromere.
- The chromosome at telophase changes from the condensed state and begins to decondense and many also gave a good description of this.

Limited responses

- Some responses were given the benefit of doubt for showing an understanding that the chromosome was a separated sister chromatid and to improve further the presence of histone proteins or the centromere needed to be noted.
- Some thought that the centromere was no longer present in the telophase chromosome.
- Some described the chromosome as being no longer visible or as being decondensed. It was only appropriate to state this if it was associated with late telophase.
- Many should have taken the time to read the question carefully. These candidates only saw 'Describe telophase of mitosis'. This meant that there were descriptions that included the behaviour of the nuclear envelopes and the nucleoli, or the location of the chromosomes at the poles of the cell.

(e) (i) Comprehensive responses

- The most accurate answer, endothelial cell, was known by a proportion of candidates.

Limited responses

- Many candidates gave the name of the cell type forming the wall of the alveolus, squamous epithelial cell, or named the tissue squamous epithelium.
- Candidates who wrote 'endothelium cell' were given the benefit of doubt as they clearly knew that the tissue was the endothelium, and had correctly noted that the question asked for the type of cell.

(ii) Comprehensive responses

- The best responses addressed both halves of the question and described clearly the change to the interstitium that would occur and how this affected the uptake of oxygen into the capillary.
- Many were able to use the terms 'diffusion', 'rate of diffusion' or 'diffusion rate' to help produce a high-quality answer.

Limited responses

- Some responses only repeated information stated in the text about an increase in ECM components and forgot to relate this to the change in the interstitium.
- Some of the descriptions of the change to the interstitium needed to be more precise. Descriptions such as 'bigger', 'increase in size' and 'longer' were not enough to confirm an understanding that the distance between the capillary wall and alveolar space had increased.
- Some wrote about a barrier and an inability of oxygen to enter the capillary.

(f) (i) Comprehensive responses

- The majority correctly identified the peptide bond as the covalent bond joining the amino acid residues.

Limited responses

- Some stated 'polypeptide' or 'dipeptide' bond, which was not acceptable, or incorrectly gave disulfide bond.
- Some candidates thought that hydrogen bonds were covalent bonds.
- Covalent bonds from other types of biological molecule, such as glycosidic bond, were seen.

(ii) Comprehensive responses

- These responses showed a clear understanding that a collagen molecule is composed of three helical polypeptides that form a compact triple helix structure, and explained precisely the importance of glycine and alanine.
- Good answers had used Figure 2.3 to help them see that alanine had a small R-group.
- Good responses did not include a description of the interactions between collagen molecules to form collagen fibres or fibrils.

Limited responses

- Some responses used the terms polypeptide and molecule as if they were interchangeable, which is not correct when describing a molecule of collagen.
- Many thought that a triple helix was composed of three collagen molecules.
- Despite having Figure 2.3, some described alanine as having the same R-group as glycine.

- Although the question was focused only on a collagen molecule, some candidates included details of collagen fibrils or fibres or wrote only about collagen fibres.
- Some candidates wrote only about the structural properties of collagen, which was not required.

Question 3

Comprehensive responses

- The best answers gave each conclusion as a separate statement and then gave clearly set-out, comparative, supporting data. The response then continued to give correct explanations about the possible effects of MeJA on the growth of the root tissue.

Limited responses

- Some gave detailed descriptions of the result shown rather than stating the conclusions that could be drawn.
- Many concentrated only on the effect of MeJA and compared this with the control, and missed out the obvious relationship between increasing NaCl concentration and the growth of the tissues.
- Some candidates could have improved their response by supporting a conclusion with the data that was given in Table 3.1.
- A number of candidates only gave conclusions based on Table 3.1 or only attempted to explain the effect of MeJA.
- Some candidates attempted to give more than one conclusion and include data in one long sentence and not always in a sequential manner, resulting in an overall response that was very muddled.

Question 4

(a) Comprehensive responses

- The most accurate answer, plasma cell, was given by a large proportion of candidates. B-lymphocyte was also accepted.

Limited responses

- Naming 'lymphocyte' was not sufficient because this could include 'T-lymphocytes' which would be incorrect.

(b) Comprehensive responses

- Many gave a completely correct sequence.

Limited responses

- Many had difficulty in deciding when screening cells for desired production of monoclonal antibody should take place. Otherwise, they were able to deduce a correct overall sequence for the hybridoma method.

(c) (i) Comprehensive responses

- The absence of purines was related well to the inability to form complementary base pairs. Good answers continued to explain one or more processes that would not be able to occur as a result, which would prevent myeloma cell division. Most of these explained that DNA replication could not occur.

Limited responses

- Some answers repeated information given in the question text, and did not progress this further with ideas that could be considered as acceptable for the response needed.

(ii) Comprehensive responses

- The most comprehensive answers began with explaining the changes that occur at the genetic level and then explained the effect of this on the structure of the synthesised, non-functional enzyme.
- The correct term was used when giving an example of the type of mutation that occurred and this was then related to the consequence to the gene for the stated mutation.

Limited responses

- Some candidates needed to read through their answer to check for careless errors. For example, the mutation of gene *HPRT* was described as a change in the sequence of genes.
- Some did not match the gene with the type of mutation they had suggested. For example, some described a base substitution and then suggested incorrectly that it caused a frameshift.
- Some candidates made up their own terms for the type of mutation that occurred. It was most common to see 'addition' for an insertion mutation.

(d)(i) Comprehensive responses

- Many knew the full name and the correct spelling of the virus that causes HIV/AIDS.

Limited responses

- There were many variations of the incorrect spelling of the virus. The most common were 'human imunodeficiency virus', 'human immunodeefficiency virus' and 'human immunodificiency virus'.

(ii) Comprehensive responses

- Answers directly focused on the question posed showed an understanding that the monoclonal antibody infusion was to protect a person rather than to treat a person who was already infected with HIV.
- Well-expressed accounts explained why the level of monoclonal antibody would decrease over time and also explained the inability of the person being given the infusion to show immunity to HIV.

Limited responses

- Many did not realise that the infusion was for protection against being infected and so described the need for continued infusions to help treat a person with the virus.
- Some erroneously thought that the infusion would stimulate the immune system of the person.

(iii) Comprehensive responses

- These showed knowledge of antibody specificity to an antigen and could explain how changing gp120 of the envelope glycoprotein by mutation would require a different antibody for successful prevention of viral entry to the host cell.
- Good answers focused their suggestions and explanations on the specific envelope glycoprotein required for host cell entry.
- Many realised that a change to gp120 could result in resistance to VRC01.

Limited responses

- Some answers could have been improved by qualifying a description of a change to HIV by explaining that mutation occurs to result in the changed antigen.
- Quite a number had not noted the importance of the envelope glycoprotein in allowing HIV to enter a host cell and gave general ideas about HIV antigens.

Question 5

(a) Comprehensive responses

- Most were careful to use Figure 5.1 to match the correct letter labelling parts of the circulatory system to the descriptions listed in Table 5.1.

Limited responses

- For those who did not correctly match all the descriptions to the correct label on Figure 5.1, it was usually because more knowledge of the blood vessels was needed.

(b)(i) Comprehensive responses

- These directly addressed the high specific heat capacity of water and described how water, as a component of blood, was able to resist changes in temperature. They then went on to qualify this further by relating this to the ability to maintain a constant body temperature and/or describing the benefit of this to a relevant example.

Limited responses

- Some showed an understanding of the meaning of specific heat capacity and needed to link this with the high specific heat capacity of water as a component of blood.
- Some mentioned the maintenance of optimum temperatures for the blood or for the body. This was not the same as maintaining a constant temperature despite external temperature changes that might occur.
- Some confused high specific heat capacity with high latent heat of vaporisation.

(ii) Comprehensive responses

- Many were able to give a full account with a sound explanation of the importance of water in mass flow.
- The correct scientific terminology was evident in the most comprehensive responses. These were used when explaining the importance of the changes of water potential at the source, the build up of hydrostatic pressure, the cohesive nature of water in mass flow, and water as a solvent for the assimilates in phloem sap.

Limited responses

- Many responses displayed a basic understanding. These needed to contain more scientific detail and needed to use the terminology stated above.
- A proportion misread the question and attempted to explain the importance of water in the transport of water in xylem.

Question 6

(a) Comprehensive responses

- Most gave accurate values for the optimum pH and for the optimum temperature, including giving the units °C, for the enzyme lactate dehydrogenase (LDH). As the percentage of maximum activity did not reach 100 for the temperature graph in Figure 6.2, a value within a range of optimum temperatures was accepted.

Limited responses

- Some did not notice that one small square was equivalent to 0.2 pH on the x-axis of Figure 6.1. This resulted in stating an incorrect value for the optimum pH for LDH.

(b) Comprehensive responses

- These responses covered how the different pHs below the optimum and above the optimum affected enzyme activity.
- The best answers explained how pH can affect R-group interactions and how pH too far below or too far above the optimum would cause hydrogen bonds and ionic bonds to break.
- Many recognised that percentage activity below 100 did not mean that the enzyme had denatured, as activity was still shown, and explained that partial denaturation was occurring.

Limited responses

- A proportion of responses gave a description of the results shown in Figure 6.1 rather than an explanation.
- Some candidates wrote about the effect of temperature, rather than pH.

(c) Comprehensive responses

- Good suggestions were given by those candidates who recalled that the enzyme ALT was the focus of the test and who remembered that this test was performed on a blood sample at room temperature.

Limited responses

- Many candidates gave an answer based on explaining the need to perform the test at body temperature, despite being told the test occurred at room temperature.
- Some candidates wrote about the effect of a high temperature on blood or its components, which was not the focus of the question.

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Paper 9700/23
AS Level Structured Questions

Key messages

What candidates did well

- Many candidates showed good understanding and knowledge of the differences between the cells of prokaryotes and eukaryotes when tackling **Questions 2(a)(i), 2(a)(ii) and 2(a)(iii)**.
- Answers to **Question 3(d)** and **Question 4(b)** demonstrated that many candidates have a good understanding of protein structure and can give correct accounts of the different levels of protein structure. Many were also able to distinguish clearly between tertiary and quaternary protein structure.
- The majority of candidates were able to identify the circulatory system found in mammals from a choice of three different types of circulatory system in **Question 5(a)**. A good proportion of these were able to justify their choice using their knowledge of the features of a double circulatory system.

What candidates needed to improve

- Collectively, the presence of many hydrogen bonds provides strength to a molecule. Candidates should not refer to hydrogen bonds, which are relatively weak bonds, as being strong bonds or covalent bonds. This incorrect reference was seen in answers to **Question 3** and **Question 4(b)**.
- When referring to movement of water in xylem vessels as in **Question 3(b)**, candidates should show an understanding of the chemical nature of the xylem vessel wall. It is important to state that water molecules can form hydrogen bonds with the hydrophilic parts of the wall, which means that cellulose should be named as the main component. It is also relevant to state that water molecules form hydrogen bonds with only the hydrophilic parts of lignin.
- Candidates should use the syllabus term transmissible when describing the spread of an infectious disease and should not use the term contagious, which generally has a more specific description of being easily transmitted. In questions such as **Question 4(a)**, although transmissible is the preferred term, communicable is also acceptable.
- Candidates should avoid using the term 'genetic code' when describing the nucleotide sequence or base sequence of a gene or of the entire genome of the organism. In **Question 4(c)(ii)**, it was not correct to state that the genetic code of gene *HPRT* had changed. It was also not sufficient to describe a change in the base sequence or nucleotide sequence of *HPRT* as a change in the gene sequence or a change in the DNA sequence.

Question 1

(a) (i) Comprehensive responses

- Some candidates studied Figure 1.1 carefully and noted that the cell labelled **A** did not have cilia, unlike the other cells in the epithelium, so could deduce that the cell was a goblet cell.

Limited responses

- Some candidates had deduced that cell **A** was not a ciliated epithelial cell and gave an unacceptable spelling, such as globet.
- The most common incorrect response for the name of cell **A** was ciliated epithelial cell.
- Some named a tissue, such as ciliated epithelium or epithelium.
- A number gave squamous epithelial cell, which is found lining the alveolus, or smooth muscle cell.

(ii) Comprehensive responses

- Tissue **B** in Figure 1.1 was generally recognised as smooth muscle.

Limited responses

- Common incorrect answers were cartilage or elastic tissue, particularly from candidates who stated that cell **A** was a smooth muscle cell.

(iii) Comprehensive responses

- Good responses presented a minimum of two reasons as to why Figure 1.1 was not an image from a bronchiole.
- The responses were very clear in identifying whether the response was written from the point of view of Figure 1.1 or a bronchiole.

Limited responses

- A reference to cartilage was made by a high proportion of candidates, who needed to explain more clearly that this was absent in the bronchiole. These answers used 'it' or 'they' within the response or just stated 'there is no cartilage'.

(b)(i) Comprehensive responses

- Many answers were clearly set out, with all the working shown and the answer given to one significant figure, as instructed.

Limited responses

- Some candidates should have noted that the columnar epithelial cell shown in Figure 1.2 had a width of 8 μm and depth of 6 μm . These used only 8 or only 6 to calculate a value for the four sides and the two ends of the cell and so arrived at an incorrect answer.
- Some used the correct values to calculate the ratio and should have remembered, or noted, that the instruction was to give the answer to one significant figure.

(ii) Comprehensive responses

- Many recognised that the high surface area-to-volume ratio of the squamous epithelial cell would improve gas exchange and gave accurate details about the advantages of this for oxygen uptake, using the scientific term diffusion.

Limited responses

- Some repeated the information given in the text and/or used non-scientific terminology such as referring to more space for gases to move. These should have referred to respiratory gases or named them and could have been clearer as to the direction of movement of the gas.

Question 2

(a)(i) Comprehensive responses

- Candidates who saw the scale bar that was given in Figure 2.1 made a valid comment about the large size of *Parakaryon myojinensis* compared to a typical prokaryotic cell.
- Some of these made a correct estimate of the length of the cell using the scale bar and compared it with the size of 1–5 μm of a typical prokaryotic cell.
- A smaller number of candidates suggested that *P. myojinensis* did not have a plasmid or plasmids, which was an acceptable answer.

Limited responses

- Many did not notice that a difference related to a nucleus or to endosymbionts was not required.

(ii) Comprehensive responses

- Many had identified the presence of ribosomes within the nucleus of *P. myojinensis*. Fewer stated that the organism possessed a nuclear membrane rather than a nuclear envelope, which is found in a eukaryotic cell.
- Others gave two examples of cell structures that were absent in prokaryotes and absent in *P. myojinensis*.

Limited responses

- Some wrote about the difference in shape of the nucleus. This was not a relevant answer as there are many differences in the shape of the nucleus in eukaryotic cells.
- Some candidates stated that *P. myojinensis* had a cell wall and should have qualified this with detail to make the statement completely correct, such as stating that animal cells do not have a cell wall.

(iii) Comprehensive responses

- Most approached this question by demonstrating an understanding that if the analysis showed the presence of murein or peptidoglycan, this would match the cell wall of prokaryotic cells, and if cellulose or chitin, this would match the cell wall of eukaryotic cells.

Limited responses

- A number incorrectly stated that prokaryotic cells have cell walls containing either cellulose or chitin.

(b) Comprehensive responses

- Some responses were well organised and gave a step-by-step outline.
- Reference to calibration of the eyepiece graticule using the stage micrometer was given by a number of candidates, while others described the procedure to use.
- In full responses, candidates knew that the stage micrometer would need to be replaced by the slide of the cell and continued with an outline of how to arrive at the actual length, including detail about the calculation that would be required.

Limited responses

- Some only described half of the required procedure, with a good proportion continuing to give the standard formula for calculating actual length or drawing out the magnification triangle.
- Some thought that the slide of the cell would need to be placed over the stage micrometer.

Question 3

(a) Comprehensive responses

- Some of the clearest answers tackled specific heat capacity and latent heat of vaporisation separately so that it was obvious which property of water was being discussed.
- Many explained that hydrogen bonding resulted in a high specific heat capacity and high latent heat of vaporisation.
- Some accounts gave relevant examples of the benefits to organisms of these properties.

Limited responses

- A proportion gave mixed sentences so that it was difficult to discern whether the explanation was referring to specific heat capacity or to latent heat of vaporisation.
- Many wrote about maintaining temperature or providing an optimum temperature and could have improved this by stating that a constant or stable blood and body temperature would be an outcome of the high specific heat capacity of water, and explaining further that water, as part of blood, can resist changes in temperature.
- Some gave a description of hydrogen bonding, which was not required.

(b) Comprehensive responses

- Full accounts indicated correctly the role of hydrogen bonding in allowing cohesion between water molecules and adhesion between water molecules and the xylem wall.
- These accounts were detailed, for example noting that adhesion involved cellulose, which is hydrophilic and that water molecules could adhere to the hydrophilic parts of lignin.
- Candidates took care to explain how these features related to the movement of a continuous, unbroken, column of water that could move against gravity.
- Many answers referred to relevant technical terms, such as transpiration pull and the transpiration stream.

Limited responses

- Some repeated detail that they had given in **Question 3(a)**, which was not relevant to the question.
- Some knew about cohesion and tension but got the meanings the wrong way round.
- Some referred to water moving down a water potential gradient and needed to provide further detail to show that the overall context was correct.

(c) Comprehensive responses

- These named fully the bases **W**, **X**, **Y** and **Z** and gave the correct spellings for all four.

Limited responses

- Some could have improved their answer by learning the correct spellings of all of the bases.
- Although some were able to deduce that the two-ringed structures were the purines adenine and guanine, and the single ringed structures were the pyrimidines cytosine and thymine, they did not know, or missed the clue given in Figure 3.1, that adenine and thymine were the bases paired by two hydrogen bonds and guanine and cytosine paired by three hydrogen bonds.

(d) Comprehensive responses

- Some completed Table 3.1 correctly, showing good knowledge and understanding of the bonds involved in the different levels of protein structure.

Limited responses

- Although many different incorrectly completed tables were seen, it was quite common to see a tick for hydrogen bonds affecting primary structure, or for hydrogen bonds to be left out of the tertiary structure column.

Question 4

(a) Comprehensive responses

- Some had read the passage carefully and had worked out that 'transmissible' and 'pathogen' were the correct terms to complete the passage. These are the two stated terms in the syllabus learning outcome in Topic 11 and were usually spelled correctly. A number stated communicable for transmissible, which was accepted.

Limited responses

- Some had read the term 'infection' at the start of **Question 4** and so used 'infectious' for one or both gaps. These had missed the fact that the word before the gap was the vowel 'a' and had also not noticed the information that stated that tetanus is unlike other diseases for which vaccines are available, which also ruled out using infectious as an answer.
- Some gave contagious for the first gap, which was rejected.
- A number wrote viral, bacterial or parasitic for the second gap, rather than pathogen.

(b) Comprehensive responses

- Well-organised responses began with primary structure and continued to cover all the other levels of protein structure, giving a clear indication as to which description belonged to which level.
- Some noted that the disulfide bridge shown in Figure 4.1 indicated that the primary structures of each polypeptide contained an amino acid, which could form a disulfide bond, with some naming cysteine as the amino acid.
- A number correctly related the presence of the disulfide bond to the quaternary structure of the tetanus toxin, having noted that this was the interaction connecting the two different polypeptide chains.
- Descriptions of secondary structure correctly limited their response to alpha-helices only.

Limited responses

- Some could have improved their answer by relating their descriptions to Figure 4.1 rather than stating general features of proteins. For example, secondary structure was described as alpha helices and beta-pleated sheets, even though no beta-pleated sheets were visible.
- Many thought that the disulfide bond shown in Figure 4.1 was part of tertiary structure.

(c) Comprehensive responses

- Most knew that the process shown in Figure 4.2 was an example of endocytosis. Phagocytosis was also accepted.

Limited responses

- The most common incorrect responses included active transport and infection.

(d) Comprehensive responses

- Many were able to match the correct types of immunity to the descriptions given in Table 4.1.

Limited responses

- Some candidates paired together active with passive and natural with artificial, which reflected a lack of understanding of the types of immunity that can be gained.
- Some candidates did not appear to realise which terms were required to complete Table 4.1 and tried to use terms to match the descriptions, for example suggesting genetic and maternal for the first description and using the term vaccine with passive or vaccine with active for the other two descriptions. Some used short-term and long-term as part of their response.

(e) Comprehensive responses

- There was some flexibility in placing the events occurring during a primary immune response in the correct order, and many candidates did well on this sequencing question.
- Most gave the correct sequence as **FBEDCA**, considering the production of T-helper cells, which would then secrete cytokines, before the production of plasma cells.

Limited responses

- A number of candidates did not appreciate the importance of the macrophage as an antigen presenting cell in the immune response, and these did not begin their sequence with events **F** and **B**.

Question 5

(a) Comprehensive responses

- Some gave complete answers, stating the correct circulatory system and giving well-expressed responses describing how this system shows that blood passes through the heart twice for every complete circuit of the body, naming the two types of circulation involved and explaining how **H** shows that the blood is contained within blood vessels.

Limited responses

- Although most knew that circulatory system **H** represents the circulatory system found in mammals, some did not express their reasons clearly. Many described blood going to the lungs to obtain oxygen and to the body to deliver oxygen and did not mention the heart and/or did not explain that this was one complete circuit.
- Some candidates linked circulatory system **H** with double circulation. The response should have been completed by explaining that **H** also showed that this was a closed system and the blood was contained within vessels.

(b) Comprehensive responses

- Thorough responses explained the ultrafiltration of plasma owing to the higher hydrostatic pressure of blood arriving at the capillary network and gave details of the substances that would form the tissue fluid.
- Many candidates understood the importance of endothelial pores in the formation of tissue fluid.

Limited responses

- Some wrote about blood being forced out of the capillary, rather than plasma, or stated that plasma left the arteriole that carried the blood at high pressure.
- Some could have improved their response by giving more detail about the filtration process that occurs, rather than using half of the response to write about the return of fluid back to the capillary network, which was not required.
- Many incorrectly used the terms osmosis and diffusion to explain the exit of substances from the capillary.

(c) Comprehensive responses

- Many were able to give a full account by describing correctly the apoplast and symplast pathways in detail, using correct scientific terminology.
- Good answers remembered to begin with water in the soil solution and end with water entering xylem tissue.
- A number of responses gave a correct sequence of tissues through which water passes across the root.
- Most candidates understood that water in the apoplast pathway enters the symplast pathway at the endodermis when it meets the suberin of the Casparian strip.

Limited responses

- Some wrote about the apoplast pathway yet began their response by stating that water moved from the soil solution by osmosis or stated that water moved from cell wall to cell wall by osmosis.
- A number thought that plasmodesmata formed part of the apoplast pathway and gave a response containing a mixture of correct and incorrect factual details.
- It was a common error to state that water travels in intracellular spaces of the apoplast pathway, rather than in the intercellular spaces.
- Water was described as moving in the symplast pathway by osmosis by a number of candidates. Osmosis should only be noted for entry into the root hair cell and for crossing tonoplasts in the vacuolar route. Similarly, for the transition from the apoplast to the symplast pathway, water enters the endodermal cells by osmosis.

Question 6

(a) Comprehensive responses

- Some gave excellent explanations, giving details specific to the role of ligase in DNA replication and balancing this with features of the mode of action of enzymes. Although not required knowledge, many used the term Okazaki fragments in the correct context.
- Some suggested the lock and key hypothesis for the mode of action of ligase, while others suggested the induced fit hypothesis: either was acceptable.

Limited responses

- Many candidates should have explained that ligase catalysed the formation of phosphodiester bonds, and should have qualified this further by stating that these allowed the fragments on the lagging strand (Okazaki fragments) to be joined.
- Some candidates focused only on enzyme action and should have related this to ligase.

(b) Comprehensive responses

- Many were able to state the three main phases in the interphase part of the cell cycle.
- Most knew that the semi-conservative replication of DNA takes place in the S phase.
- The most organised answers gave a sequential account, outlining events occurring in the phases as they would occur during a cell cycle.

Limited responses

- Many candidates omitted to state that the replication of organelles takes place in the G1 and G2 phases, although many showed knowledge of growth of the cell.
- A proportion of candidates misread the question and thought they were being asked to outline the events occurring in the stages of mitosis, so that no details of any events occurring in interphase were given.

(c) (i) Comprehensive responses

- Practically all knew that cell **Q** in Figure 6.2 was in the metaphase stage of mitosis.

Limited responses

- The most common error was to name the stage as anaphase, although a number opted for prophase.

(ii) Comprehensive responses

- This question asked for the process happening in a particular region, **R**, of a cell shown in Figure 6.2. Candidates who had read the question carefully were able to correctly suggest that the cell plate was forming, or that the cell wall was forming.
- Some candidates realised that the plant cell was in the process of dividing into two, so a reference to cytokinesis was allowed for the answer.

Limited responses

- Some candidates missed the information in the question about region **R** and thought that they were being asked to name the stage of mitosis in cell **R**. This meant that a number of candidates stated telophase, or even anaphase, as their answer.
- Some candidates attempted to describe cytokinesis and gave descriptions such as 'cell splitting into two', which was not accepted.

BIOLOGY

Paper 9700/24
AS Level Structured Questions

Key messages

What candidates did well

- In **Question 1(b)**, candidates coped well with the unfamiliar photomicrograph of cells in a stage of the mitotic cell cycle. They were able to find evidence in the photomicrograph to deduce that the cells were animal cells and then described features that were visible to confirm that the cell was in the telophase-cytokinesis part of the cycle, rather than in early interphase.
- Candidates were able to use the information provided about the activity of cholesterol oxidase to complete the substrate concentration graph in **Question 2(b)(i)**. The curve sketched in was accurately drawn to reflect the activity of an enzyme with the specific $V_{\max}$ stated, and which could be used to derive the Michaelis-Menten constant (K_m). This demonstrated good understanding of the subject matter assessed.
- **Questions 6(b)(i)** and **(b)(ii)** assessed Topic 2 of the syllabus, Biological molecules. Candidates demonstrated good knowledge of the biological molecules listed in Table 6.1 and could correctly match the molecule to one of the bonds stated in the table. They were also able to compare the molecules to identify and explain which pair had most features in common.

What candidates needed to improve

- Some candidates incorrectly thought that chromatin was an alternative term to chromatid. In **Question 1(a)(i)**, sister chromatids should not have been referred to as sister chromatins. In the telophase stage shown in Figure 1.1, the sister chromatids had already been separated at anaphase. In the answer to **Question 1(b)**, these could now be called daughter chromosomes or chromosomes as these would now have their own centromere ready to proceed to interphase.
- The term water potential, and not concentration of water, should have been used to answer **Question 5(a)(ii)**. Some candidates also needed to understand that water goes down a water potential gradient and that the gradient exists between the root cell with a higher water potential and the adjacent cell with a lower water potential. It is not correct to state that water moves from a high water potential gradient to a low water potential gradient.
- Candidates should make sure that, when writing the abbreviation for alpha, α , and for beta, β , these symbols do not look like the lowercase a and b of the alphabet. It was not always easy in **Question 6(b)** if the candidate was naming the monomer of amylopectin and glycogen as 'a glucose' or was using the alpha abbreviation to give α -glucose. Also in **Question 6(d)**, the reverse was true: some answers appeared to name B-lymphocytes as β -lymphocytes, and in instances such as these, it is important to write clearly the uppercase letter B.

Question 1

(a) (i) Comprehensive responses

- Most made reference to the need for the cell to carry out DNA replication to produce sister or identical chromatids before the start of mitosis and then explained why this was necessary.
- Some made reference to having to pass checkpoints, while others stated the desired outcome of producing genetically identical daughter cells.

Limited responses

- Many focused only on the anaphase stage where sister chromatids were separated and needed to continue with this idea to show that this would produce the genetically identical daughter cells.

(ii) Comprehensive responses

- Many were able to name correctly the two enzymes stated in the learning outcome in Topic 5 of the syllabus.

- As a result of extension knowledge, a proportion chose to name another enzyme, the most common of which was helicase.

Limited responses

- Some candidates did not give the full name DNA ligase and only stated ligase.

(iii) Comprehensive responses

- After naming correctly the phase of interphase where histone proteins are synthesised, some candidates qualified this further to demonstrate an understanding that these histone proteins would be complexed with DNA during the S-phase to produce the sister chromatids for mitosis.
- Some candidates had background knowledge of the role of histone proteins in the condensation of the chromosome in prophase.

Limited responses

- Some candidates gave a response that was too vague by indicating that histones were proteins and that protein synthesis occurred during the G1 phase. This statement needed to relate histone proteins to their importance in becoming complexed with DNA during the S phase.

(b) Comprehensive responses

- It was clear that many candidates had studied Figure 1.1 carefully and used visible evidence to support the incorrect observations stated in the question.
- There were correct suggestions of the stage of the cell cycle shown in Figure 1.1, with some candidates showing an understanding that there is often an overlap between the end of telophase of mitosis and the beginning of cytokinesis of the cell cycle.
- Most realised that the lack of a cell wall or cell plate meant that the image was of animal cells.

Limited responses

- Figure 1.1 showed daughter chromosomes (separated sister chromatids) in two locations some distance apart and decided that the stage of mitosis shown was anaphase. These candidates did not notice that the presence of a distinct cleavage furrow would indicate a later stage in the cell cycle.
- Some candidates incorrectly assumed that the lack of chloroplasts or a large central vacuole confirmed the presence of animal cells. Not all plant cells have these features.
- Some candidates who identified Figure 1.1 as showing the telophase stage of mitosis and/or cytokinesis, or incorrectly identified anaphase, attempted to give a textbook description rather than use visible features. A proportion of these forgot to address the observations stated in the question.

Question 2

(a) Comprehensive responses

- Most knew the correct term 'extracellular' for the type of enzyme described and were able to spell this correctly.

Limited responses

- Exocellular and excellular were considered to be too far from the correct term, and exocytosis was rejected as it has a very different meaning.

(b)(i) Comprehensive responses

- Many understood how the Michaelis-Menten constant (K_m) could be derived from the graph of cholesterol oxidase activity at different substrate concentrations, so could use the information given in the question to sketch an accurate curve on Figure 2.1 and complete the x-axis label.

Limited responses

- Some of the curves sketched on Figure 2.1 showed a continued increase to 0.5 mmol dm^{-3} and should have shown that a plateau of 580 U cm^{-3} was reached before this point.
- Some candidates should have double-checked the units given for substrate concentration. These candidates stated the units as mol dm^{-3} or $\mu\text{mol dm}^{-3}$.

(ii) Comprehensive responses

- There were a few candidates who fully addressed the conclusion stated in the question.
- These candidates began their response with 'I agree...' or 'I do not agree...' so it was clear from the beginning how the response should develop.
- The support for their decision was taken from Figure 2.2, with data accurately extracted.
- Reference was made to the food industry to give a complete response.

Limited responses

- Some candidates should have stated whether or not they had agreed with the conclusion made by the candidate. This meant that when values extracted from Figure 1.1 or Figure 2.2 were given, it was sometimes difficult to decide whether the candidate was supporting or not supporting the conclusion.
- There were plotted points for all the pH values shown on Figure 2.1, so it was relatively straightforward to extract data accurately. Candidates should have given absolute values rather than translating these as, for example, below 20 per cent or above 90 per cent.

(c) Comprehensive responses

- Most candidates knew that the cell surface membrane of the human host cells of *Mycobacterium tuberculosis* contained cholesterol as one of its components. This allowed them to deduce from their knowledge of the role of the molecule that the properties of the membrane would change in favour of entry of the pathogen into the cell.
- Descriptions of how the pathogen could enter the cell as a result of changes to the membrane were clear. Most wrote about endocytosis or described gaps that would be produced to allow the pathogen to pass through directly.
- There were also a proportion who considered how the secretion of cholesterol oxidase by the pathogen, or the presence of the pathogen once inside the cell, would cause harm to the host cell. A few did suggest damage to the other intracellular membranes, with others realising that the pathogen would be using up respiratory substrates for its own metabolism.

Limited responses

- Some stated that reducing the content of cholesterol in the cell surface membrane would decrease membrane fluidity, with some also contradicting this idea within the response by stating that permeability would increase. Re-reading the response may have alerted these candidates to amend their answer.
- Some described fusion of the pathogen membrane with the host cell membrane. With some extra thought, these candidates may then have realised that fusion of the membranes would not result in entry of the whole bacterial cell.

(d) Comprehensive responses

- There were some excellent answers that suggested a variety of potential benefits of the drug therapy based on a chemical affecting cholesterol oxidase. These were also qualified with solid explanations.
- Many realised how the drug therapy would make a positive impact on the problems created by antibiotic-resistant strains of the pathogen.

Limited responses

- Some suggested a benefit without commenting that this was due to the inability of the pathogen to enter the host cell.
- Some wrote only about the benefit to the person who had been infected and should have addressed the aspect of control of the spread of the disease, which was part of the question.

Question 3

(a) Comprehensive responses

- These responses were detailed and focused on ways individuals can prevent infection by *Vibrio cholerae*. Some of the ways suggested showed understanding of the faecal-oral route of transmission of the disease.

Limited responses

- Some knew that prevention included washing hands and should have qualified this with more detail. Cleaning hands was not an acceptable alternative to washing hands.

- A proportion did not read the question carefully enough and wrote a response explaining the benefit of vaccines.

(b)(i) Comprehensive responses

- Many realised the statement made by the candidate could only be agreed or challenged if all case fatality rates (CFRs) were known and made the decision to calculate these to arrive at the correct answer
- Full accounts used calculated values and data from Table 3.1 to explain how they did not agree with the statement given in the question.

Limited responses

- Some candidates made errors in their calculation and should have checked these.
- A decision to agree with the statement was given some consideration only when the correct data taken from Table 3.1 was quoted in the response. This had to include the CFR values.

(ii) Comprehensive responses

- Answers of a high standard remained focused on a response considering only people who already had cholera.
- Many wrote comparative statements about oral rehydration therapy and antibiotics.
- References to the quality of water in the different countries considered how taking in contaminated water could increase the risk of death in a person with cholera.

Limited responses

- Many did not answer the question posed about differences in CFR and gave accounts of how cholera could be prevented and controlled.
- Some responses needed more detail to highlight differences. A good proportion of these repeated the wording of the question text about availability and quality of treatment without continuing to give valid examples.

(c)(i) Comprehensive responses

- Some had learned the explanation of a gene given in the learning outcome of the syllabus and so found this a straightforward question.

Limited responses

- Many appeared to make up their own definition of a gene, with only a few including some acceptable information. Most were very general and wrote about special areas of DNA or producing features or containing a code, or other vague or incorrect ideas.
- Some stated that a gene makes proteins rather than codes for a protein.
- Some attempted to give an explanation of a genome.

(ii) Comprehensive responses

- These answers considered structural features present in a *V. cholerae* cell and remembered to omit reference to a plasmid. This is because they recognised that a plasmid is circular, double-stranded DNA and had noted that the instruction meant this should not be included in the response.

Limited responses

- Many listed structural features absent from a *V. cholerae* cell, which was not required.

Question 4

(a) Comprehensive responses

- Many were able to use Figure 4.1 to extract a correct value for the percentage saturation of haemoglobin with oxygen in the 13.2 kPa to 13.3 kPa range of partial pressure of oxygen and to show understanding that this reflected a high affinity for oxygen by haemoglobin.
- A number of candidates made correct reference to a steep diffusion gradient, with fewer adding the important detail about the arrival of blood with a low partial pressure of oxygen.

Limited responses

- Many should have given an accurate value for the percentage saturation of haemoglobin or should have explained that a haemoglobin molecule can bind four oxygen molecules at these

high partial pressures. Instead, they wrote about haemoglobin being fully saturated, which was not enough detail.

- Some needed to use scientific terminology such as diffusion and concentration gradients when writing about the uptake of oxygen.

(b)(i) Comprehensive responses

- Most candidates who arrived at the correct calculated value also remembered to show their working.
- Most candidates extracted the correct values from Figure 4.1.

Limited responses

- Although this was a straightforward calculation, some candidates appeared to be confused by the reference to percentage saturation. These carried out the correct subtraction, then divided it by the higher value and finally multiplied by 100.

(ii) Comprehensive responses

- Some realised that a change in pO_2 would be caused when the oxygen required by a tissue was not balanced by the oxygen delivered to the tissue. Most suggested an event occurring within cells or the tissue, such as respiration rate rather than a change to the rate of flow of blood arriving at the tissue.

Limited responses

- Some gave ideas that were too general, such as doing exercise.
- Some suggested a factor that would have a general effect on the body, such as altitude.
- Those that suggested carbon dioxide concentration should have linked this to the event occurring in the tissue, such as increased tissue activity or respiration rate.

(c) Comprehensive responses

- Most knew the blood vessel was the vena cava and the majority were able to spell this correctly.

Limited responses

- Some candidates named the blood vessel as vana cava, which was not accepted.
- Pulmonary artery or pulmonary vein were the most common incorrect answers.

Question 5

(a)(i) Comprehensive responses

- Candidates found this a straightforward question and the majority gave the correct terms to match the descriptions.

Limited responses

- Some candidates gave incorrect spellings of facilitated diffusion, the most common being facillitated diffusion, facillated diffusion and faciliated diffusion.
- Some gave active transport or passive diffusion instead of facilitated diffusion.
- A number stated apoplast pathway or symplast pathway instead of osmosis.

(ii) Comprehensive responses

- Clear answers explained that water would move through plasmodesmata from the root cell to the adjacent cell down a water potential gradient, or from a high water potential to a low water potential.

Limited responses

- Some candidates wrote about water concentration rather than water potential.
- Some confused water potential with water potential gradient and stated that water would move from a high water potential gradient to a low water potential gradient, which was not acceptable.

(b)(i) Comprehensive responses

- Once a candidate had correctly identified the name of the layer of cells as the endodermis, then there was flexibility in stating the role of suberin. Most were able to give an acceptable answer.

Limited responses

- Some needed to read the question more carefully and stated the name of the cell rather than the name of the layer of cells.
- A number of candidates incorrectly thought that the Casparian strip was the name of the layer of cells.
- Some candidates began with a correct explanation of the role of suberin and then contradicted themselves by using apoplast to mean symplast and vice versa.

(ii) Comprehensive responses

- Some candidates were able to recall the distribution of tissues in a TS of a root of a herbaceous dicotyledon. They were able to study Figure 5.1 to describe a number of correct similarities and differences.
- High-quality responses were clear in their description of the location of the tissues and made sure that each similarity was stated in a separate sentence (or bullet point) and each difference was stated in one comparative sentence or two short descriptive sentences.

Limited responses

- Many gave only a short account for this extended response, possibly reflecting that additional knowledge was required to give a more complete answer.
- Some had not noticed the pith in the centre of Figure 5.1 and described the vascular tissue as being located in the centre, incorrectly citing this as a similarity to a TS of a herbaceous dicotyledon root. Others thought that the herbaceous dicotyledon had a pith.
- Some candidates drew a cross-section of a dicotyledon root. This could have helped their response considerably if they had annotated their diagram to clarify, and/or had sketched the monocotyledon root to show differences.

Question 6

(a) Comprehensive responses

- The majority showed an understanding of what is meant by macromolecules.
- There were some accurate descriptions of why only proteins and polysaccharides of the three named molecule types could be described as polymers. These included the idea that the molecules were composed of repeating subunits.
- For this question it was also acceptable to use amino acids as examples for proteins and monosaccharides as examples for polysaccharides, which some did. Some had already explained about repeating subunits and made sure their answer was comprehensive by giving the examples, and by describing the components of triglycerides as lipids.

Limited responses

- Some explained that polymers were composed of subunits and needed to add that these were repeating.
- Some tried to give explanations of polymers in terms of molecule shape or the number of different types of component smaller molecules.

(b)(i) Comprehensive responses

- Many had good knowledge of the type of biological molecule that was represented by each of the listed examples and ticked the correct type of bond present.

Limited responses

- Some candidates ignored the instruction to use one tick in each row.
- Most knew that glycogen had glycosidic bonds and triglycerides had ester bonds.
- It was common for candidates to tick two bond types for amylopectin and/or cellulose.

(ii) Comprehensive responses

- Most candidates who correctly deduced amylopectin and glycogen did continue to give a correct explanation, with some giving a number of correct similarities.

Limited responses

- Some candidates correctly stated amylopectin and glycogen and included an incorrect feature in addition to correct similarities, which was not accepted.
- A number matched amylopectin or glycogen with cellulose, and if a correct reason was given then this was given some consideration.

(c) Comprehensive responses

- Some candidates stated goblet cells and mucous glands as structures producing mucus, which was more precise than stating the names of two airways, which was also accepted.

Limited responses

- Many stated goblet cells and another structure, which was not correct, such as ciliated cells.
- There were a number of incorrect spellings of goblet, which were not acceptable, such as globet and globlet.
- Some who named airways needed to spell these correctly.

(d) Comprehensive responses

- There were some excellent accounts of the features of an antigen, with some candidates covering a range of correct ideas.
- The responses included accurate descriptions of activation of T-lymphocytes and/or B-lymphocytes as part of an immune response.

Limited responses

- Many had only some idea of the features of an antigen, with only a proportion mentioning antibodies.
- A high proportion of candidates thought that the location of an antigen was on the surface of an antigen-presenting cell.
- Some candidates incorrectly thought that antigens had receptors to bind to antibodies.

BIOLOGY

Paper 9700/31 Advanced Practical Skills
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Key messages

Manipulation, measurement and observation

What candidates did well

- Most candidates decided on a suitable number of values for the independent variable and the intervals between them.
- Many candidates took readings to collect accurate data.
- Many candidates set up a light microscope to view specimens and followed instructions to find and draw particular tissues and cells.

What candidates needed to improve

- Many candidates needed to collect two results for each concentration.
- Many candidates needed to understand the purpose of the control in this investigation to answer this question.
- Many candidates needed to draw plan diagrams that showed the correct distribution and proportion of layers of tissue.
- Some candidates needed to draw cells with the correct shape and relative sizes.
- Some candidates needed to understand the use of a scale bar when calculating the actual size of a tissue from a photomicrograph.

Presentation of data and observations

What candidates did well

- Many candidates recorded their raw results in an appropriate table with descriptive headings, including the required units, with the heading for the independent variable to the left of the dependent variable.
- Many candidates displayed the given data as a bar chart with labels for the independent and dependent variables matching the relevant table headings and all bars plotted accurately with clear, unbroken lines.

What candidates needed to improve

- Candidates should practise drawing the fine details of the stem.
- Some candidates needed to show all the steps in the calculation.

Analysis, conclusions and evaluation

What candidates did well

- Many candidates compared observable features on the section on slide J1 with the differences between the section in Figure 2.2.

What candidates needed to improve

- Candidates need to practise identifying the main sources of error in a particular investigation and suggest improvements to the errors.
- Many candidates were able to make predictions from the patterns and trends in data. They should consider the data carefully and be able to suggest an explanation.

Comments on specific questions

Question 1

(a) (i) Comprehensive responses

- Most candidates were able to select appropriate concentrations of hydrogen peroxide to prepare, using proportional dilution of the 1.0% hydrogen peroxide solution.
- Most responses demonstrated knowledge of using the correct volumes of the 1.0% hydrogen peroxide solution and water to make the chosen concentrations.

Limited responses

- A few candidates needed to understand that the volumes of the 1.0% hydrogen peroxide solution and water stated should accurately make the concentrations selected.

(ii) Comprehensive responses

- Some candidates drew an appropriate table with the number of drops recorded twice for each concentration of hydrogen peroxide prepared and used their results to calculate a mean.

Limited responses

- Many candidates needed to understand that two results should be recorded for each concentration prepared which could then be used to calculate a mean for use in **Question 1(a)(iv)**.

(iii) Comprehensive responses

- Most candidates understood that they needed to state the number of drops for the unknown concentration, **U**
- Many candidates demonstrated that the experiment had been carefully carried out by stating a suitable value.

(iv) Comprehensive responses

- Most candidates demonstrated a good knowledge of how to estimate an unknown concentration using their results of the known hydrogen peroxide concentrations.

Limited responses

- Some responses needed to show that the estimated concentration could be stated as being between two known concentrations.

(v) Comprehensive responses

- Some candidates were able to describe a suitable control.

Limited responses

- Some candidates needed to understand that **P** should be replaced or inactivated.
- Some candidates needed to understand that hydrogen peroxide should still be present.

(vi) Comprehensive responses

- Some candidates were able to identify two errors and improvements.

Limited responses

- Many candidates needed to refer to the specified steps in the procedure to identify the errors and suggest improvements.

(vii) Comprehensive responses

- Some candidates were able to explain how the increase in substrate concentration would lead to more enzyme-substrate complexes and increase the number of drops released.

Limited responses

- Many candidates needed to explain why the number of drops would increase.

(b)(i) Comprehensive responses

- Many candidates were able to label the axes, select the correct scale for the y-axis, plot the 6 points accurately and group the bars appropriately.

Limited responses

- Some candidates needed to include all of the labels or include a key for the bars.
- Some candidates needed to draw bars precisely.

(ii) Comprehensive responses

- Many candidates stated whether the data supported the conclusion or not and gave appropriate examples.

Limited responses

- Some candidates needed to interpret the data rather than just quote it.
- Candidates needed to refer to the information provided at the beginning of the question and think about the quality of the data to help them provide an answer.

Question 2

(a)(i) Comprehensive responses

- Some candidates were able to show that they had used the microscope to identify the many layers of tissue, including the number of layers around the stem and the position of the vascular bundles.

Limited responses

- Many responses needed to show that they had observed all the tissues of the stem and taken into account the relative size and location of these tissues.

(ii) Comprehensive responses

- Some candidates demonstrated good knowledge of what was required to make a large drawing of four cells.

Limited responses

- Some candidates need to develop their skills when observing and recording the fine details of cells. The shape and proportion of the different cells needed to be represented in the final drawings.

(b)(i) Comprehensive responses

- Some excellent responses included detailed descriptions of observable differences between the section on **J1** and the section in Figure 2.2.

Limited responses

- Some candidates needed to be able to select observable differences between **J1** and Figure 2.2 that could be clearly described.

(ii) Comprehensive responses

- Some responses identified an appropriate observable feature and suggested a suitable function.

Limited responses

- Many candidates needed to show a greater understanding of the advantage to some plants of having a hollow stem.

(c) Comprehensive responses

- Many excellent responses included correct measurements of the diameter of the central region and the length of the scale bar.
- Many responses also showed how to calculate the actual diameter of the central region.

Limited responses

- Some candidates needed to understand how to use the scale bar to calculate the actual diameter of the central region.

BIOLOGY

Paper 9700/32 Advanced Practical Skills
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Key messages

Manipulation, measurement and observation

What candidates did well

- Most candidates demonstrated their skills by showing how to prepare different concentrations of vitamin C.
- Many candidates took readings to collect accurate data.
- Many candidates set up a light microscope to view the specimen and followed instructions to find and draw particular tissues and cells and labelled the drawing appropriately.

What candidates needed to improve

- Some candidates needed to collect results to the nearest 0.01 cm^3 .
- Many candidates needed to draw plan diagrams that showed the correct distribution and proportion of layers of tissue.
- Some candidates needed to draw cells with the correct shape and include a cuticle.
- Some candidates needed to understand how to use the eyepiece graticule scale placed across a photomicrograph.

Presentation of data and observations

What candidates did well

- Many candidates recorded their raw results in an appropriate table with descriptive headings, including the required units, with the heading for the independent variable to the left of the dependent variable.
- Many candidates displayed the given data as a bar chart with labels for the independent and dependent variables matching the relevant table headings and all bars plotted accurately with clear, unbroken lines.

What candidates needed to improve

- Many candidates needed to show greater understanding of selecting an appropriate scale, where both axes should use most or all of the grid available and allow the graph to be read easily to within half a square.
- Candidates should practise drawing the fine details of the leaf.
- Some candidates needed to show all the steps in the calculation.

Analysis, conclusions and evaluation

What candidates did well

- Many candidates compared observable features on the section on slide **K1** with the differences between the section in Figure 2.1.

What candidates needed to improve

- Candidates need to practise interpreting results from investigations and given data.
- They should consider the data carefully and be able to explain the data and make valid conclusions from the data.
- Candidates need to understand how to calculate an answer with the correct number of significant figures.

Comments on specific questions

Question 1

(a) (i) Comprehensive responses

- Many candidates were able to show how to prepare the correct percentage concentrations of vitamin C solution by completing Figure 1.1.

Limited responses

- Some candidates needed to state the volumes of **C** and **W** required to dilute the previous concentration by half.

(ii) Comprehensive responses

- Many candidates recorded their results in a table with the appropriate headings and correctly recorded the volume of vitamin C needed to reach the end-point for each concentration, to the nearest 0.01 cm³.

Limited responses

- Some candidates needed to understand that units such as % and cm³ should not be in the body of the table.
- Some candidates needed to understand that the volume of vitamin C should be recorded to 0.01 cm³.

(iii) Comprehensive responses

- Most candidates understood that they needed to state the volumes of **U** and boiled **U** to reach the end-point.

Limited responses

- Some candidates needed to understand that the volumes should be similar to their results in **Question 1(a)(ii)**.

(iv) Comprehensive responses

- Many candidates were able to correctly estimate the concentration of vitamin C in **U** and in boiled **U**.

Limited responses

- Some candidates needed to refer to their results in **Question 1(a)(ii)** and **1(a)(iii)** to estimate the concentration of vitamin C.

(v) Comprehensive responses

- Some candidates were able to explain the results in **Question 1(a)(iv)**.

Limited responses

- Some candidates needed to refer to their results in **Question 1(a)(iv)** before suggesting a suitable explanation.

(vi) Comprehensive responses

- Some candidates were able to suggest a reason for determining the end-point before carrying out the investigation.

Limited responses

- Many candidates needed to consider how determining the end-point would help them in the investigation.
- Some candidates needed to be more precise in their answer when suggesting that it could be used as a control.

(vii) Comprehensive responses

- Many candidates understood that the volume of drops is not always the same.

Limited responses

- Some candidates needed to understand that the question was asking why drops were less accurate than volume and not about counting.

(b)(i) Comprehensive responses

- Some candidates were able to select appropriate scales for the x-axis and the y-axis, plot the 5 points accurately and draw a line through these points.

Limited responses

- Some candidates did not select the appropriate scales for either the x-axis or the y-axis. The scale chosen for both axes should be linear and use most or all of the grid.
- Candidates should consider that the most appropriate scale may not start at 0 for line graphs.

(ii) Comprehensive responses

- Many candidates concluded that the concentration of vitamin C in the blood increased as the mass of vitamin C in the tablet increased.
- Some candidates understood that vitamin C was present in the blood without taking vitamin C tablets.

Limited responses

- Many candidates needed to show greater understanding of the data shown in the graph.
- Some candidates needed to state a conclusion which could be supported by quoted data.

(iii) Comprehensive responses

- Some candidates showed how to calculate an increase of 50 per cent.
- Some candidates were able to estimate the mass of vitamin C from the graph.

Limited responses

- Some candidates omitted to show the calculation.
- Many candidates used the incorrect concentration of vitamin C ($202 \mu\text{mol dm}^{-3}$) for the calculation.
- Many candidates had selected an incorrect scale on the graph making it impossible to be read easily to half a small square.

(iv) Comprehensive responses

- Some candidates suggested an advantage.

Limited responses

- Many candidates needed to consider a reason why the results might be more accurate.

Question 2

(a)(i) Comprehensive responses

- Many candidates were able to show that they had used the microscope to identify the many layers of tissue, including the central vascular area and the layer of palisade tissue extending around the leaf.

Limited responses

- Some candidates needed to show that they had observed all the tissues of the leaf and taken into account the relative size and proportions of these layers.

(ii) Comprehensive responses

- Some candidates demonstrated good knowledge of what was needed to make a large drawing of two epidermal cells, two hypodermal cells and the cuticle.

Limited responses

- Many candidates needed to include the cuticle in the drawing.
- Many candidates needed to develop their skills when observing and recording the fine details of cells. The shape of the different cells and the size of the cell walls needed to be represented in their final drawings.

(iii) Comprehensive responses

- Some excellent responses included detailed descriptions of observable differences between the section on **K1** and the section in Figure 2.1.

Limited responses

- Some candidates needed to select observable differences between the section on **K1** and the section in Figure 2.1 that could clearly be described.

(b)(i) Comprehensive responses

- Many candidates were able to calculate the length of one eyepiece graticule unit using Figure 2.2.

Limited responses

- Some candidates measured the eyepiece graticule scale and included units.
- Some candidates needed to show the calculation.

(ii) Comprehensive responses

- Some candidates were able to use the eyepiece graticule placed across the photomicrograph in Figure 2.3 to calculate the actual length of the lumen of the resin duct.

Limited responses

- Some candidates measured the length of the eyepiece graticule scale covering the whole photomicrograph.
- Some candidates measured the eyepiece graticule scale and included units.
- Some candidates needed to understand how to give their answer to two significant figures.

BIOLOGY

Paper 9700/33 Advanced Practical Skills
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Key messages

What candidates did well

- Most candidates demonstrated their skills by showing how to prepare different concentrations of hydrogen peroxide.
- Many candidates recorded their raw results in an appropriate table with descriptive headings, including the required units, with the heading for the independent variable, per cent concentration of hydrogen peroxide, to the left of (or above, if the table is in rows) the dependent variable, time/seconds.
- Most candidates described the trend correctly using the data provided in their tables.
- Many candidates correctly identified the main source of error in their investigation.
- Many candidates drew the bar chart precisely.
- Many candidates showed their ability using the microscope to find and draw particular tissues in a plant specimen and label the drawing appropriately.
- Many candidates showed they could follow instructions to find and draw particular cells within a tissue.

What candidates needed to improve

- Some candidates needed to explain the relationship between the enzyme catalase and the breakdown of the substrate, hydrogen peroxide, more clearly.
- Some candidates drew large plan diagrams that were imprecise and needed to include more details of the internal tissues of the leaf.

3 Enzymes

3.1 Mode of action of enzymes

Learning outcomes

- Candidates should be able to explain the mode of action of enzymes in terms of active sites and enzyme-substrate complexes.

What candidates did well

- Many candidates provided very good answers when explaining the trend in their results by showing a clear understanding of the increase in the number of enzyme-substrate complexes with an increase in the number of substrate molecules.

What candidates needed to improve

- Some candidates needed to consider providing more details concerning the mode of action of enzymes.

Comments on specific questions

Question 1

(a) (i) Comprehensive responses

- Many candidates were able to show how to prepare the percentage concentrations of hydrogen peroxide when completing Table 1.2. Many responses demonstrated knowledge of adding the correct volumes of **H** and the correct volumes of water.

Limited responses

- Some candidates needed to understand that the final volume of each hydrogen peroxide concentration should be 10 cm³.

(ii) Comprehensive responses

- Many candidates understood that the heading for the independent variable had to be to the left of the heading for the dependent variable and that a time should be recorded for each concentration of hydrogen peroxide prepared.

Limited responses

- Many candidates needed to understand that two results needed to be recorded for each concentration of hydrogen peroxide prepared.
- Some candidates needed to understand that units such as per cent and seconds should not be recorded in the body of their results table.
- Some candidates needed to understand that the time taken to reach the 5 cm mark was not required.

(iii) Comprehensive responses

- Many excellent responses expressed the trend shown by their results.

Limited responses

- Some candidates needed to explain the trend by referring to the amount of substrate present and the formation of enzyme-substrate complexes.

(iv) Comprehensive responses

- Many candidates were able to identify a source of error in the procedure.

Limited responses

- Some candidates needed to refer to the procedure of the practical to identify a source of error correctly.

(v) Comprehensive responses

- Many candidates were able to draw a labelled diagram of the apparatus to measure the volume of oxygen given off and included a suitable piece of apparatus to collect the gas.

Limited responses

- Some candidates needed to understand that describing how to count the number of bubbles of oxygen would not enable the volume of oxygen to be measured.

(b)(i) Comprehensive responses

- Many candidates were able to select appropriate scales for the x-axis and the y-axis, plot the 5 points accurately and draw separate bars.

Limited responses

- Some candidates omitted labels for the x-axis or the y-axis.

(ii) Comprehensive responses

- Many candidates understood that the microorganisms A and C were able to break down the hydrogen peroxide.

Limited responses

- Some candidates needed to refer to the information provided at the beginning of the question to help them provide an answer.

Question 2

(a)(i) Comprehensive responses

- Some candidates were able to show that they had used the microscope to identify the many layers of tissue, including the central vascular area and the layer of palisade tissue extending around the leaf.

Limited responses

- Many responses needed to show that they had observed all the tissues of the leaf and taken into account the relative size and proportions of these layers.

(ii) Comprehensive responses

- Some candidates demonstrated good knowledge of what was required to make a large drawing of four epidermal cells.

Limited responses

- Some candidates needed to develop their skills when observing and recording the fine details of cells. The shape and proportion of the different cells needed to be represented in their final drawings.

(b)(i) Comprehensive responses

- Some excellent responses included detailed descriptions of observable differences between the section on **L1** and the section in Figure 2.1.

Limited responses

- Some candidates needed to be able to select observable differences between **L1** and Figure 2.1 that could be clearly described.

(ii) Comprehensive responses

- Some candidates demonstrated good observation skills when identifying plant organ **L1** and the plant organ shown in Figure 2.1.

Limited responses

- Some candidates needed to show a greater understanding of the features that differentiate between a leaf, a stem and a root.

(c)(i) Comprehensive responses

- Many candidates were able to correctly state the diameter of the whole section and the diameter of the central region and include appropriate units.

Limited responses

- Some candidates needed to understand that measurements needed to be recorded in millimetres or centimetres.

(ii) Comprehensive responses

- Some candidates were able to show how to calculate the area of the central region.

Limited responses

- Some candidates needed to understand that showing their working was required.

(iii) Comprehensive responses

- Some candidates were able to state the ratio correctly.

Limited responses

- Some candidates needed to understand how to express a ratio.

BIOLOGY

Paper 9700/34 Advanced Practical Skills
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Key messages

What candidates did well

- Many candidates recorded their raw results in an appropriate table with descriptive headings, including the required units, with the heading for the independent variable, temperature/°C, to the left of (or above, if the table is in rows) the dependent variable, colour intensity.
- Most candidates described the trend correctly using the data provided in their tables.
- Many candidates correctly suggested improvements to the two main sources of error in their investigation.
- Many candidates showed their ability using the microscope to find and draw particular tissues in a plant specimen and label the drawing of the stem appropriately.
- Many candidates showed their ability to calculate the actual diameter of the stem and the central space and then to calculate the actual area of the cortex.

What candidates needed to improve

- Some candidates needed to show greater understanding of the roles of phospholipids and proteins in the cell surface membrane.
- Many candidates needed to show a greater understanding of selecting an appropriate scale where both axes should use most or all of the grid available and allow the graph to be read easily to within half a square.
- Some candidates needed to observe the cells selected more carefully and ensure that their drawings showed the precise shape of these particular cells.

4 Cell membranes and transport

4.1 Fluid mosaic membranes

Learning outcomes

Candidates should be able to:

- Describe the fluid mosaic model of membrane structure with reference to the hydrophobic and hydrophilic interactions that account for the formation of the phospholipid bilayer and the arrangement of proteins.
- Describe the roles of phospholipids, proteins and glycoproteins in cell surface membranes, with reference to stability, fluidity and permeability.

What candidates did well

- Many candidates provided good answers when explaining the effect of temperature on the release of stain from the potato tissue.

What candidates needed to improve

- Some candidates needed to understand that stating that more stain came out of the potato when the temperature was increased was describing what had occurred and not giving an explanation of how this had occurred.

Comments on specific questions

Question 1

(a) (i) Comprehensive responses

- Many candidates correctly stated three other temperatures to use in the investigation.

Limited responses

- Some candidates needed to understand that the temperatures selected needed to be at least 5 °C apart.

(ii) Comprehensive responses

- Many candidates correctly recorded their results in a table with the appropriate headings and correctly recorded intensity as symbols.

Limited responses

- Some candidates needed to understand that units, such as °C, should not appear in the body of the table.

(iii) Comprehensive responses

- Many excellent responses correctly stated the independent variable in the experiment.

Limited responses

- Some candidates needed to understand the difference between the independent and dependent variables.

(iv) Comprehensive responses

- Many excellent responses expressed the trend shown by their results.

Limited responses

- Some candidates needed to understand how to correctly express a trend.

(v) Comprehensive responses

- Some responses demonstrated knowledge of the composition of a cell membrane and the effect of temperature on the phospholipids and proteins within it.

Limited responses

- Many responses needed to show a greater understanding of the effect of heat on the diffusion of particles.

(vi) Comprehensive responses

- Many candidates fully understood why the water needed to be pale blue or colourless.

Limited responses

- Some candidates needed to provide more details in their answers.

(vii) Comprehensive responses

- Many candidates understood that confidence in the results could be increased by identifying and excluding anomalous results.

Limited responses

- Some candidates needed to understand that repeating the procedure several times and finding the mean would not completely eliminate errors.

(viii) Comprehensive responses

- There were many excellent responses that correctly stated improvements to judge the intensity of colour and the maintenance of temperature throughout the procedure.

Limited responses

- Some candidates needed to be more precise when suggesting how to make improvements to procedures in the investigation.

(b)(i) Comprehensive responses

- Many candidates were able to select appropriate scales for the x-axis and the y-axis, plot the 5 points accurately and draw a line through these points.

Limited responses

- Some candidates did not select the appropriate scales for either the x-axis or the y-axis.

The scale chosen for both axes should allow most or all of the grid to be available.

(ii) Comprehensive responses

- Many candidates were able to estimate the percentage of dye removed at pH 7.

Limited responses

- Some candidates needed to understand that the scale chosen should allow the graph to be read easily to within half a square.

Question 2

(a) (i) Comprehensive responses

- Some candidates were able to show that they had used the microscope to identify the many layers of tissue, including the vascular areas towards the epidermis.
- Many excellent responses included many of the tissue layers in the correct proportion.

Limited responses

- Many responses needed to show that they had observed all the tissue layers of the stem, including the large number of vascular bundles present.

(ii) Comprehensive responses

- Some candidates demonstrated good knowledge of what was required to make a large drawing of four xylem vessel elements.

Limited responses

- Some candidates needed to develop their skills when observing and recording the fine details of cells. The shape of the different cells needed to be represented in the final drawings.

(b) Comprehensive responses

- Some excellent responses included detailed descriptions of observable differences between the section on **M1** and the section in Figure 2.1.

Limited responses

- Some candidates needed to be able to select observable differences between **M1** and Figure 2.1 that could be clearly described.

(c) (i) Comprehensive responses

- Many excellent responses included correct measurements of the diameters of the stem and central space with the appropriate units. Many responses also demonstrated how to calculate the actual diameters.

Limited responses

- Candidates need to understand that all measurements need to be accompanied by the appropriate units and need to be recorded in millimetres or centimetres.

(ii) Comprehensive responses

- Many responses demonstrated knowledge of what is required to calculate the actual area of the cortex.

Limited responses

- Some candidates needed to understand how to give their answer to three significant figures.

(iii) Comprehensive responses

- Some responses demonstrated knowledge of plant structure and the advantage of having a hollow stem.

Limited responses

- Many responses needed to show a greater understanding of plant structure.

BIOLOGY

Paper 9700/35 Advanced Practical Skills
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Key messages

What candidates did well

- Most candidates demonstrated their skills by preparing different concentrations of citric acid.
- Many candidates recorded their raw results in an appropriate table with descriptive headings, including the required units, with the heading for the independent variable, per cent concentration of citric acid, to the left of (or above, if the table is in rows) the dependent variable, clotting intensity.
- Most candidates described the trend correctly using the data provided in their tables.
- Many candidates correctly identified the main source of error in their investigation.
- Many candidates drew the graph precisely with each of the lines on the graph labelled correctly and used the graph correctly to find an unknown value.
- Many candidates showed their ability using the microscope to find and draw particular tissues in a plant specimen and label the drawing appropriately.
- Many candidates showed they could follow instructions to find and draw particular cells within a tissue.
- Some candidates showed their ability to use a scale bar to calculate the actual area of a stem.

What candidates needed to improve

- Some candidates incorrectly included units in the body of their table of results.
- Many candidates needed to consider how to modify an investigation to overcome the difficulties of measuring the mass of such a small amount of clotted milk.
- Some candidates needed to identify each of the lines on the graph using appropriate labels.
- Some candidates drew large plan diagrams that were imprecise and needed to include more details of the internal tissues of the stem.
- Some candidates drew large drawings of cells that were imprecise.
- Many candidates needed to understand how to state their answer to two significant figures.

2 Biological molecules

2.3 Proteins

Learning outcomes

- Candidates should be able to explain the meaning of the terms primary structure, secondary structure, tertiary structure and quaternary structure of proteins.

What candidates did well

- Many candidates provided very good answers by recording their results in an appropriate table, using the number scale, accurately describing the trend in their results and identifying a source of error when judging the clotting intensity.

What candidates needed to improve

- Some candidates needed to be better able to modify a procedure to change what is being measured in an investigation, in this case determining the mass of clotted milk formed with 0.25 per cent citric acid.

Comments on specific questions

Question 1

(a) (i) Comprehensive responses

- Many candidates were able to complete Table 1.2 by stating at least three other concentrations of citric acid. Many responses demonstrated knowledge of adding the correct volumes of C and the correct volumes of W.

Limited responses

- Some candidates needed to understand that selecting some particular percentage concentrations of citric acid, such as 0.15625, would involve adding 6.25 cm³ of C to 3.75 cm³ of W, which would be impractical.

(ii) Comprehensive responses

- Many candidates understood that the heading for the independent variable had to be to the left of the heading for the dependent variable and that a clotting intensity should be recorded for each concentration of citric acid prepared.

Limited responses

- Candidates needed to understand that units such as per cent should not be recorded in the body of their results table.

(iii) Comprehensive responses

- Many excellent responses accurately described the trend shown by their results.

Limited responses

- Some candidates needed to understand how to correctly express a trend.

(iv) Comprehensive responses

- Many candidates were able to correctly identify a source of error when deciding the clotting intensity.

Limited responses

- Some candidates needed to consider providing more details when describing the nature of the error.

(v) Comprehensive responses

- Most candidates were able to record the clotting intensity for L.

Limited responses

- Some candidates needed to understand that they needed to select a number between 0 and 5 when recording a clotting intensity.

(vi) Comprehensive responses

- Most candidates were able to correctly estimate the concentration of citric acid in lemon juice L.

Limited responses

- Some candidates needed to refer to their results in **Questions 1(a)(ii)** and **1(a)(v)** to estimate the clotting intensity.

(vii) Comprehensive responses

- A few candidates were able to clearly outline how to modify the procedure to determine the mass of clotted milk formed with 0.25 per cent citric acid.

Limited responses

- Many candidates needed to consider how to overcome the difficulties of using such a small volume of milk and citric acid and suggest modifications to overcome these difficulties.

(b) (i) Comprehensive responses

- Some candidates were able to plot all the points accurately and draw a line through them.

Limited responses

- Some candidates omitted labels for the lines on the graph representing the results at 22 °C and 30 °C.

(ii) Comprehensive responses

- Many candidates were able to estimate the pH of the milk incubated at 30 °C when it started to clot.

Limited responses

- Many candidates needed to show on their graph how they obtained their estimate of the pH.

(iii) Comprehensive responses

- Many candidates were able to use the pH of the milk incubated at 30 °C to estimate the time at which the milk kept at 22 °C started to clot.

Limited responses

- Many candidates had selected an incorrect scale, making it impossible to read off the graph.

Question 2

(a) (i) Comprehensive responses

- Some candidates were able to show that they had used the microscope skilfully to identify the many layers of tissue, including the band of vascular area within the stem.

Limited responses

- Many candidates needed to show that they had observed all the tissues of the stem and identified the location of the xylem tissue.

(ii) Comprehensive responses

- Some candidates demonstrated good knowledge of what was required to make a large drawing of four xylem vessel elements.

Limited responses

- Some candidates needed to develop their skills when observing and recording the fine details of cells. The shape and proportion of the different cells needed to be represented in the final drawings.

(b) (i) Comprehensive responses

- There were many excellent responses which included correct measurements of the diameter of the stem with the appropriate units.

Limited responses

- Candidates need to understand that these measurements need to be recorded with the appropriate units and need to be recorded in millimetres or centimetres.

(ii) Comprehensive responses

- Many responses demonstrated knowledge of what was required to calculate the actual area of the stem.

Limited responses

- Some candidates needed to understand how to give their answer to two significant figures.

(iii) Comprehensive responses

- There were some excellent responses that included detailed descriptions of observable differences between the section on **N1** and the section in Figure 2.1.

Limited responses

- Some candidates needed to be able to select observable differences between **N1** and Figure 2.1 that could be clearly described.

BIOLOGY

Paper 9700/37 Advanced Practical Skills
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Key messages

What candidates did well

- Most candidates demonstrated their skills by showing how to prepare different concentrations of hydrogen peroxide.
- Many candidates recorded their raw results in an appropriate table with descriptive headings, including the required units, with the heading for the independent variable, per cent concentration of hydrogen peroxide, to the left of (or above, if the table is in rows) the dependent variable, time/seconds.
- Most candidates described the trend correctly using the data provided in their tables.
- Many candidates correctly identified the main source of error in their investigation.
- Many candidates drew the bar chart precisely.
- Many candidates showed their ability using the microscope to find and draw particular tissues in a plant specimen and label the drawing appropriately.
- Many candidates showed they could follow instructions to find and draw particular cells within a tissue.

What candidates needed to improve

- Some candidates needed to explain the relationship between the enzyme catalase and the breakdown of the substrate, hydrogen peroxide, more clearly.
- Some candidates drew large plan diagrams that were imprecise and needed to include more details of the internal tissues of the leaf.

3 Enzymes

3.1 Mode of action of enzymes

Learning outcomes

- Candidates should be able to explain the mode of action of enzymes in terms of active sites and enzyme-substrate complexes.

What candidates did well

- Many candidates provided very good answers when explaining the trend in their results by showing a clear understanding of the increase in the number of enzyme-substrate complexes with an increase in the number of substrate molecules.

What candidates needed to improve

- Some candidates needed to consider providing more details concerning the mode of action of enzymes.

Comments on specific questions

Question 1

(a) (i) Comprehensive responses

- Many candidates were able to show how to prepare the percentage concentrations of hydrogen peroxide when completing Table 1.2. Many responses demonstrated knowledge of adding the correct volumes of H and the correct volumes of water.

Limited responses

- Some candidates needed to understand that the final volume of each hydrogen peroxide concentration should be 10 cm³.

(ii) Comprehensive responses

- Many candidates understood that the heading for the independent variable had to be to the left of the heading for the dependent variable and that a time should be recorded for each concentration of hydrogen peroxide prepared.

Limited responses

- Many candidates needed to understand that two results needed to be recorded for each concentration of hydrogen peroxide prepared.
- Some candidates needed to understand that units such as per cent and seconds should not be recorded in the body of their results table.
- Some candidates needed to understand that the time taken to reach the 5 cm mark was not required.

(iii) Comprehensive responses

- Many excellent responses expressed the trend shown by their results.

Limited responses

- Some candidates needed to explain the trend by referring to the amount of substrate present and the formation of enzyme-substrate complexes.

(iv) Comprehensive responses

- Many candidates were able to identify a source of error in the procedure.

Limited responses

- Some candidates needed to refer to the procedure of the practical to identify a source of error correctly.

(v) Comprehensive responses

- Many candidates were able to draw a labelled diagram of the apparatus to measure the volume of oxygen given off and included a suitable piece of apparatus to collect the gas.

Limited responses

- Some candidates needed to understand that describing how to count the number of bubbles of oxygen would not enable the volume of oxygen to be measured.

(b)(i) Comprehensive responses

- Many candidates were able to select appropriate scales for the x-axis and the y-axis, plot the 5 points accurately and draw separate bars.

Limited responses

- Some candidates omitted labels for the x-axis or the y-axis.

(ii) Comprehensive responses

- Many candidates understood that the microorganisms A and C were able to break down the hydrogen peroxide.

Limited responses

- Some candidates needed to refer to the information provided at the beginning of the question to help them provide an answer.

Question 2

(a)(i) Comprehensive responses

- Some candidates were able to show that they had used the microscope to identify the many layers of tissue, including the central vascular area and the layer of palisade tissue extending around the leaf.

Limited responses

- Many responses needed to show that they had observed all the tissues of the leaf and taken into account the relative size and proportions of these layers.

(ii) Comprehensive responses

- Some candidates demonstrated good knowledge of what was required to make a large drawing of four epidermal cells.

Limited responses

- Some candidates needed to develop their skills when observing and recording the fine details of cells. The shape and proportion of the different cells needed to be represented in their final drawings.

(b)(i) Comprehensive responses

- Some excellent responses included detailed descriptions of observable differences between the section on **L1** and the section in Figure 2.1.

Limited responses

- Some candidates needed to be able to select observable differences between **L1** and Figure 2.1 that could be clearly described.

(ii) Comprehensive responses

- Some candidates demonstrated good observation skills when identifying plant organ **L1** and the plant organ shown in Figure 2.1.

Limited responses

- Some candidates needed to show a greater understanding of the features that differentiate between a leaf, a stem and a root.

(c)(i) Comprehensive responses

- Many candidates were able to correctly state the diameter of the whole section and the diameter of the central region and include appropriate units.

Limited responses

- Some candidates needed to understand that measurements needed to be recorded in millimetres or centimetres.

(ii) Comprehensive responses

- Some candidates were able to show how to calculate the area of the central region.

Limited responses

- Some candidates needed to understand that showing their working was required.

(iii) Comprehensive responses

- Some candidates were able to state the ratio correctly.

Limited responses

- Some candidates needed to understand how to express a ratio.

BIOLOGY

Paper 9700/38 Advanced Practical Skills
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Key messages

What candidates did well

- Many candidates recorded their raw results in an appropriate table with descriptive headings, including the required units, with the heading for the independent variable, temperature/°C, to the left of (or above, if the table is in rows) the dependent variable, colour intensity.
- Most candidates described the trend correctly using the data provided in their tables.
- Many candidates correctly suggested improvements to the two main sources of error in their investigation.
- Many candidates showed their ability using the microscope to find and draw particular tissues in a plant specimen and label the drawing of the stem appropriately.
- Many candidates showed their ability to calculate the actual diameter of the stem and the central space and then to calculate the actual area of the cortex.

What candidates needed to improve

- Some candidates needed to show greater understanding of the roles of phospholipids and proteins in the cell surface membrane.
- Many candidates needed to show a greater understanding of selecting an appropriate scale where both axes should use most or all of the grid available and allow the graph to be read easily to within half a square.
- Some candidates needed to observe the cells selected more carefully and ensure that their drawings showed the precise shape of these particular cells.

4 Cell membranes and transport

4.1 Fluid mosaic membranes

Learning outcomes

Candidates should be able to:

- Describe the fluid mosaic model of membrane structure with reference to the hydrophobic and hydrophilic interactions that account for the formation of the phospholipid bilayer and the arrangement of proteins.
- Describe the roles of phospholipids, proteins and glycoproteins in cell surface membranes, with reference to stability, fluidity and permeability.

What candidates did well

- Many candidates provided good answers when explaining the effect of temperature on the release of stain from the potato tissue.

What candidates needed to improve

- Some candidates needed to understand that stating that more stain came out of the potato when the temperature was increased was describing what had occurred and not giving an explanation of how this had occurred.

Comments on specific questions

Question 1

(a) (i) Comprehensive responses

- Many candidates correctly stated three other temperatures to use in the investigation.

Limited responses

- Some candidates needed to understand that the temperatures selected needed to be at least 5 °C apart.

(ii) Comprehensive responses

- Many candidates correctly recorded their results in a table with the appropriate headings and correctly recorded intensity as symbols.

Limited responses

- Some candidates needed to understand that units, such as °C, should not appear in the body of the table.

(iii) Comprehensive responses

- Many excellent responses correctly stated the independent variable in the experiment.

Limited responses

- Some candidates needed to understand the difference between the independent and dependent variables.

(iv) Comprehensive responses

- Many excellent responses expressed the trend shown by their results.

Limited responses

- Some candidates needed to understand how to correctly express a trend.

(v) Comprehensive responses

- Some responses demonstrated knowledge of the composition of a cell membrane and the effect of temperature on the phospholipids and proteins within it.

Limited responses

- Many responses needed to show a greater understanding of the effect of heat on the diffusion of particles.

(vi) Comprehensive responses

- Many candidates fully understood why the water needed to be pale blue or colourless.

Limited responses

- Some candidates needed to provide more details in their answers.

(vii) Comprehensive responses

- Many candidates understood that confidence in the results could be increased by identifying and excluding anomalous results.

Limited responses

- Some candidates needed to understand that repeating the procedure several times and finding the mean would not completely eliminate errors.

(viii) Comprehensive responses

- There were many excellent responses that correctly stated improvements to judge the intensity of colour and the maintenance of temperature throughout the procedure.

Limited responses

- Some candidates needed to be more precise when suggesting how to make improvements to procedures in the investigation.

(b)(i) Comprehensive responses

- Many candidates were able to select appropriate scales for the x-axis and the y-axis, plot the 5 points accurately and draw a line through these points.

Limited responses

- Some candidates did not select the appropriate scales for either the x-axis or the y-axis.

The scale chosen for both axes should allow most or all of the grid to be available.

(ii) Comprehensive responses

- Many candidates were able to estimate the percentage of dye removed at pH 7.

Limited responses

- Some candidates needed to understand that the scale chosen should allow the graph to be read easily to within half a square.

Question 2

(a) (i) Comprehensive responses

- Some candidates were able to show that they had used the microscope to identify the many layers of tissue, including the vascular areas towards the epidermis.
- Many excellent responses included many of the tissue layers in the correct proportion.

Limited responses

- Many responses needed to show that they had observed all the tissue layers of the stem, including the large number of vascular bundles present.

(ii) Comprehensive responses

- Some candidates demonstrated good knowledge of what was required to make a large drawing of four xylem vessel elements.

Limited responses

- Some candidates needed to develop their skills when observing and recording the fine details of cells. The shape of the different cells needed to be represented in the final drawings.

(b) Comprehensive responses

- Some excellent responses included detailed descriptions of observable differences between the section on **M1** and the section in Figure 2.1.

Limited responses

- Some candidates needed to be able to select observable differences between **M1** and Figure 2.1 that could be clearly described.

(c) (i) Comprehensive responses

- Many excellent responses included correct measurements of the diameters of the stem and central space with the appropriate units. Many responses also demonstrated how to calculate the actual diameters.

Limited responses

- Candidates need to understand that all measurements need to be accompanied by the appropriate units and need to be recorded in millimetres or centimetres.

(ii) Comprehensive responses

- Many responses demonstrated knowledge of what is required to calculate the actual area of the cortex.

Limited responses

- Some candidates needed to understand how to give their answer to three significant figures.

(iii) Comprehensive responses

- Some responses demonstrated knowledge of plant structure and the advantage of having a hollow stem.

Limited responses

- Many responses needed to show a greater understanding of plant structure.

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Key messages

What candidates did well

- Candidates were most successful in satisfying assessment objective 1, showing recall of relevant facts.
- This was particularly the case when the required knowledge could be expressed as single words or very short answers, as in **Question 1(b)**, **Question 2(a)(i)**, **Question 8(b)** and **Question 9(b)(ii)**.
- Many candidates were able to give detailed, unambiguous descriptions of biological processes, as in **Question 2(b)(ii)** and **Question 7(b)**.
- Most candidates could apply knowledge and understanding of genetic inheritance in **Question 5(a)** and **Question 5(b)(i)**.
- Most candidates could apply the principles of Linnaean classification in **Question 6(a)(i)**.
- Most candidates were able to calculate and interpret RQ values in **Question 9(c)(i)** and **Question 9(c)(ii)**.
- Some candidates were able to apply their pre-existing knowledge appropriately in the new contexts presented in **Question 3(a)(ii)**, **Question 3(b)** and **Question 7(a)(ii)**.

What candidates needed to improve

- Candidates need to consider whether their answers are complete, listing all relevant products, for example in **Question 1(a)**.
- Candidates need to consider whether their answers are worded clearly enough, using the correct terminology, for example, basal membrane or basement membrane in **Question 2(b)(ii)** and light availability or light intensity in **Question 7(a)(ii)**.
- Candidates need to be familiar with carrying out the steps of core practical procedures, such as paper chromatography of chloroplast pigments, and the reasons for each step.
- Candidates should read the question carefully and ensure they are following any instructions given, such as commenting on how one variable changes on a graph rather than two, as in **Question 3(a)(i)**.
- Candidates should be familiar with and respond appropriately to the different command words used, for example, to evaluate the information given in **Question 6(b)**.
- Candidates should be made aware that if a question asks for a fixed number of responses, only that number of answers will be marked, so in **Question 9(a)**, for example, only the first two answers were marked.

Comments on specific questions

Question 1

(a) Comprehensive responses

- Candidates named the locations and products of the stages of respiration.

Limited responses

- Candidates wrote a partial answer such as 'matrix' or 'mitochondrion' instead of specifying the mitochondrial matrix.
- One or more products were missed from some stages.

(b) Comprehensive responses

- Candidates identified the ion, membrane and process.

Limited responses

- Some candidates named an incorrect ion.
- Some ignored the context of photosynthesis and wrote 'inner mitochondrial membrane'.
- Some wrote 'diffusion' only instead of facilitated diffusion, or incorrectly stated active transport.

Question 2

(a) (i) Comprehensive responses

- Candidates identified the initial receptor, coordination system, final receptor and response.

Limited responses

- The initial receptor was sometimes incorrectly identified as the pituitary gland.
- The pituitary gland was sometimes mentioned as the final effector instead of the collecting duct.
- Some responses missed out the idea that *more* water is reabsorbed.
- Candidates who described the response as the addition of aquaporins needed to say these were added to the *membrane* of the collecting duct or distal convoluted tubule.

(ii) Comprehensive responses

- The responses of cells to both a rise and a fall in water potential were described.

Limited responses

- Candidates referred to cells bursting or shrinking without stating the context.
- Some mentioned the importance of water as a solvent without stating a cell or metabolic reaction context.
- Some restricted their explanation to physiology with a reference to water potential homeostasis affecting blood pressure, for example.
- Very general answers mentioned dehydration and the unspecified role of water in the body.

(b) (i) Comprehensive responses

- Candidates multiplied the three figures together to calculate the mass of glucose filtered in one day.

Limited responses

- The commonest incorrect answer was 0.9 g, which represented the mass of glucose in 1 dm³.
- Candidates needed to multiply 0.9 g by 200 to find the mass per day.

(ii) Comprehensive responses

- These stated that glucose is reabsorbed from the proximal convoluted tubule (PCT) into the blood.
- The locations of sodium ions and glucose were described accurately as being, at different times, in the lumen of the tubule, inside the cells of the PCT, in the tissue fluid outside the tubule or in the blood plasma inside a capillary.
- The directions of movement of sodium ions and glucose were described and the processes by which movements occurred were named.
- The stages in reabsorption were described in a logical sequence.
- Candidates used the terms lumen, luminal or apical membrane, basal or basolateral membrane and capillary endothelium to clarify where movements occurred.

Limited responses

- Some candidates wrote mainly or entirely about ultrafiltration at the glomerulus and Bowman's capsule.
- Some answers described ion and glucose movements without referring to the PCT or to the PCT cells across which movements occur.
- The term 'basement membrane' was used instead of 'basal membrane' to refer to the PCT cell membrane closest to the blood capillary.
- Active transport of sodium ions was described as occurring through channel proteins.
- Movement of sodium was described without stating sodium ion or giving the symbol for the sodium ion, Na⁺.

Question 3

(a) (i) Comprehensive responses

- Candidates used Figure 3.1 to quote the times and mean stomatal aperture widths with their correct units at the key points during the day (start, peak and finish).
- Candidates suggested that stomata opened wider in conditions of bright or increasing light to obtain carbon dioxide for photosynthesis.
- Candidates suggested that stomatal aperture width decreases in conditions of low or decreasing light to decrease water loss by transpiration.
- Candidates commented on how the relationship between light intensity and the rate of photosynthesis affects the need for carbon dioxide.

Limited responses

- Some candidates wasted time writing about the concentration of potassium ions as well as mean stomatal aperture width.
- Some answers did not suggest reasons for the changes in mean stomatal aperture width.
- A few candidates reasoned incorrectly that stomata open to let in light.
- Words were used with less precision, for example, stating that stomata close to *prevent* water loss entirely rather than to decrease it.

(ii) Comprehensive responses

- Candidates gave a sequential cause-and-effect explanation for the observed correlation.
- They described potassium ions moving into the guard cell and how this led to water entry by osmosis, which increased the turgidity of the guard cells and led to the opening of stomata.

Limited responses

- Candidates used the terms guard cells and stomata interchangeably.
- Candidates stated the correlation relationship mentioned in the question without giving an explanation of the intermediate events.
- They did not explain how a change in the concentration of potassium ions led to a sequence of events to produce the observed effect on mean stomatal aperture width.

(b) Comprehensive responses

- Candidates stated that abscisic acid (ABA) increased when light intensity decreased and this caused guard cells to become flaccid or stomata to close.
- Candidates described the mechanism of ABA action in terms of hydrogen ion, calcium ion and potassium ion movements.

Limited responses

- Candidates did not mention ion movements associated with ABA action on guard cells.
- Candidates stated that ABA would increase when light intensity was increasing (and stomata opened wider) or did not state clearly in what light conditions ABA would increase.
- Candidates wrote about when ABA would decrease instead of when it would increase, as asked for in the question.

Question 4

(a) Comprehensive responses

- Candidates described the key aspects of chromatography and explained how R_f values could be calculated and compared with known reference values to identify pigments from a leaf.

Limited responses

- Candidates wasted time writing about how to prepare a leaf extract. The question stated that the student was provided with a prepared leaf extract.
- Candidates did not clearly state that the leaf extract must be placed on the pencil baseline or that the solvent needs to be beneath the pencil baseline at the start.
- Candidates did not mention needing to wait for the solvent to move through the paper or the need to remove it before the solvent reaches the top of the paper.
- Candidates did not mention needing to draw a line at the top of the paper to mark the final position of the solvent front before the solvent dried and became invisible.
- Some candidates incorrectly named water as a suitable solvent for plant leaf pigments.

- A few candidates incorrectly referred to using a dye to visualise the coloured pigments.
- In explaining how to calculate an R_f value, some candidates wrote 'solvent' (incorrect) or 'solute' (imprecise) instead of the specific term 'pigment'.

(b) Comprehensive responses

- Many candidates wrote comprehensive responses.
- They identified chlorophyll a as the primary pigment and one or all of the other pigments named on Figure 4.1 as accessory pigments.
- They explained that the role of these pigments is to absorb light for photophosphorylation.
- They referred to the range of pigments being able to absorb a greater range of wavelengths of light than a single pigment.

Limited responses

- Some candidates named chlorophyll b as a primary pigment instead of an accessory pigment.
- Some candidates attempted to describe the role of accessory pigments and incorrectly stated that electrons are passed between pigments in a light-harvesting cluster.

Question 5

(a) Comprehensive responses

- Most candidates listed all four correct genotypes.

Limited responses

- Some listed additional incorrect genotypes.

(b)(i) Comprehensive responses

- Most stated the genotype and phenotype correctly on the appropriate answer lines.

Limited responses

- A few wrote the phenotype in the genotype answer space and vice versa.

(ii) Comprehensive responses

- Few responses showing competent understanding were seen.
- Some mentioned that independent assortment would occur in metaphase 1.
- A very small number of answers listed the four types of gametes produced by the F₁ parent.

Limited responses

- Those who mentioned independent assortment in metaphase 1 did not link this to the two genes having to be on different chromosomes for this to happen, such as the student's assumption that the two genes were unlinked.
- Instead, most answers also mentioned crossing-over in prophase 1, which would only be relevant if the situation concerned two genes on the same chromosome.
- Answers that mentioned both independent assortment and crossing-over showed limited understanding of the topic or engagement with the question.

(iii) Comprehensive responses

- Few candidates gave the correct response that the genes were in fact linked.
- A minority explained correctly that, as there were no recombinants (all offspring showed the parental phenotypes of the initial cross), crossing-over in the F₁ parent never occurred, meaning that the genes were very close together on the same chromosome.

Limited responses

- Some candidates who correctly stated linkage wrote that there were more parental phenotypes, rather than all parental phenotypes.
- Some wrote linkage and then contradicted the information given in the question by stating that crossing-over occurred to produce recombinants.
- Some candidates stated sex linkage without justification.

(c) Comprehensive responses

- Candidates made extensive, careful use of Figure 5.2 to develop their answer and were consistent in the logic displayed.
- Answers stated a habitat (woodland or rough grass) and identified one or more phenotypic characteristics of the commonest snails in that habitat.
- It was stated that these snails were selected for and that they survived and reproduced in that habitat.
- These snail phenotypes were stated to increase in frequency, or the alleles responsible for these phenotypes were stated to increase in frequency in the population.

Limited responses

- There was a contradiction in the type of snail said to be selected for in a given habitat, e.g. Figure 5.2 shows that in rough grass the commonest traits are yellow and having stripes. Some candidates made an error and stated a contradictory mixture of traits not supported by the data, such as yellow and no stripes being commonest in rough grass or brown plus stripes in woodland.
- The most limited responses gave a general answer about selection, survival and reproduction that did not make any use of Figure 5.2 or interpret its meaning.

Question 6

(a) (i) Comprehensive responses

- Most candidates filled in the domain name and the genus and species names in Table 6.1.

Limited responses

- Some attempts to spell Eukarya were non-phonetic and unacceptable.
- Some candidates either did not know that the second part of a species name needs a small initial letter or were not careful enough with their handwriting to make the small 'f' for '*fulgens*' unambiguously small.

(ii) Comprehensive responses

- Candidates pointed out that the classification depended on morphological or DNA similarities shared between red panda and the other species in the order Carnivora, as well as the descent of red pandas and fellow members of the order from a common ancestor.
- The dietary adaptation of red pandas described in the question was seen as a later specialist development that did not negate the evolutionary relationship of red pandas to other members of the order Carnivora.

Limited responses

- Many candidates were confused because they did not distinguish between the words carnivore or carnivorous, relating to feeding habits, and the concept introduced in the question of a taxonomic grouping called the order Carnivora.
- Some answers stated that red pandas had sharp teeth or that red pandas would eat meat if provided with it, or that insects and small animals are present on bamboo, making red pandas carnivorous.
- These answers were preoccupied with diet rather than the focus of the question, which was the reasons organisms are classified together in groups.

(b) Comprehensive responses

- There were very few comprehensive responses that applied a value judgement to whether past conservation efforts were successful.
- Some relevant points about the difficulty of introducing zoo-bred animals to the wild were made.

Limited responses

- Most responses did not evaluate past efforts and say what was successful or unsuccessful about actions and results from past years.
- Many answers were written in the future tense, saying what should be done, not what was done well or badly in the past.
- Some answers explained why the red panda should be conserved, which did not answer the question set.

- Many responses relied heavily on repeating question stem information without adding any level of interpretation or analysis, for example, repeating the information that habitat was lost without saying that those responsible for conservation did not succeed in stopping this habitat loss or in restoring or protecting red panda habitat.

(c) Comprehensive responses

- Candidates described assisted reproduction practices such as in vitro fertilisation (IVF), artificial insemination (AI) and embryo transfer using correct biological terms and an appropriate level of anatomical detail.
- Candidates described the use of surrogate mothers of the same or a different, more common species.
- Candidates wrote about the role of these techniques in maintaining genetic diversity in captive-bred populations, for example, when distant zoos exchange frozen red panda semen samples.

Limited responses

- The terms and locations of the uterus, endometrium, vagina, cervix and ovary were confused.
- The meanings of the terms *gamete*, *zygote* and *embryo* were not fully understood, for example, when answers stated that after in vitro fertilisation a *gamete* or *zygote* is returned to the uterus.
- Candidates referred to sperm banks and frozen zoos without relating them to their role in conserving genetic diversity.

Question 7

(a) (i) Comprehensive responses

- Candidates read the numbers of cases of poisoning for the correct two years from the long-term trend line in Figure 7.1, found the difference and divided this by the initial number of cases, then multiplied by 100.
- They expressed their final percentage change answer to three significant figures (163%).

Limited responses

- Candidates read from the annual bars rather than the long-term trend line as instructed.
- Candidates read figures from the graph inaccurately.
- Candidates divided by the final figure for 2018 rather than the initial figure for 1986.
- Some candidates calculated a rate of change per year by dividing by the number of years between 1986 and 2018.
- Some candidates did not round their answer to three significant figures.

(ii) Comprehensive responses

- Candidates named two abiotic factors that are listed on the syllabus as limiting factors on the rate of photosynthesis, for example light intensity, temperature or carbon dioxide concentration.
- They gave reasons why these factors affect the rate of photosynthesis, specifying the precise stage of photosynthesis affected.

Limited responses

- Candidates were imprecise in naming abiotic factors, stating 'light availability' or 'amount of sunlight' instead of light intensity, 'carbon dioxide levels' instead of carbon dioxide concentration and 'how hot or cold it is' instead of temperature.
- Candidates did not specify the stage of photosynthesis affected or identify or describe the concept of the *rate* of photosynthesis.
- Some candidates suggested biotic factors such as competitors or 'predators'.
- Some candidates suggested a shortage of water as an abiotic factor, despite *Alexandrium* being described as aquatic and living in seawater.

(b) Comprehensive responses

- Candidates integrated all the information in the question with their mental model of a neuromuscular junction.
- This enabled them to name the presynaptic neurone as a motor neurone and the neurotransmitter as acetylcholine.
- Candidates linked the blocking of voltage-gated sodium ion channels in the motor neurone with muscle paralysis by detailing how the intermediate steps were stopped.
- They included correct references to stopping the entry of calcium ions, exocytosis, acetylcholine-receptor binding and T-tubule depolarisation.
- Terminology was used correctly, for example, sarcolemma for the postsynaptic membrane.

Limited responses

- Candidates described ions no longer moving 'into a membrane', rather than no longer passing *through* the axon membrane into the axoplasm inside.
- Candidates wrote about sodium or calcium without specifying ions in each case or giving the symbols for these ions.
- Some candidates confused voltage-gated channels with ligand-gated channels and started their answer at the muscle cell.
- A few candidates incorrectly called the muscle cell the postsynaptic neurone or referred to the muscle cell membrane using the incorrect term 'postsynaptic knob'.
- Some candidates wrote that the toxin mimicked acetylcholine despite the question stem information stating that it blocked voltage-gated sodium ion channels.
- Many candidates wrote at length about events that normally occur after the release of calcium ions from the sarcoplasmic reticulum (referencing troponin, tropomyosin, actin and myosin), although the question asked how the toxin prevents the release of calcium ions, not what comes afterwards.

Question 8

(a) (i) Comprehensive responses

- Candidates used correct terminology such as detection of a stimulus, development of a receptor or generator potential and the role of the sensory receptor cell as a transducer of energy.

Limited responses

- Candidates wrote that an action potential would be generated without identifying the correct context of within a sensory neurone.
- A few stated that a stimulus was passed on to the next neurone.

(ii) Comprehensive responses

- Candidates responded to 'regulating gene expression' in the question by identifying the molecules involved, naming a transcription factor or repressor protein that helped or prevented the binding of RNA polymerase.
- Some explained that the gene would code for an enzyme involved in lipid or scent molecule synthesis.

Limited responses

- Candidates repeated the question wording and wrote that the gene was expressed or not expressed, without explaining what this meant or how this control occurred.
- Some stated the gene coded for a lipid.
- Some referred to DNA polymerase instead of RNA polymerase and occasionally handwriting made it difficult to see which of these enzymes was referred to.

(b) Comprehensive responses

- Candidates identified **A**, **B** and **C** as mRNA, cDNA and probe.

Limited responses

- Some candidates did not specify the type of RNA in chemical **A**.
- Some did not specify that the DNA in **B** was single-stranded or complementary.
- Some candidates wrote primer or promoter instead of probe for **C**.

Question 9

(a) Comprehensive responses

- Candidates stated two different anabolic reactions, such as one involved in building polynucleotides (such as transcription or DNA replication) and one involved in building polypeptides (such as translation or just 'protein synthesis').
- Glycogenesis and formation of triglycerides were given as examples in some answers.

Limited responses

- Candidates listed ATP-requiring processes that are not anabolic (building) reactions, such as active transport and muscle contraction.
- Some suggested reactions that are catabolic, involving the breakdown of molecules into smaller parts, such as glycolysis and respiration.
- Some ignored the question instruction to list *two* reactions and gave incorrect answers first, followed by correct ones that did not count, since only the first two answers were marked.

(b)(i) Comprehensive responses

- Most candidates realised that the adult needed more ATP because it could move and was larger in size.
- A few mentioned nerve impulse generation or reproduction as requiring ATP.

Limited responses

- Candidates suggested one reason rather than two.

(ii) Comprehensive responses

- Many candidates stated both substrate-linked phosphorylation and oxidative phosphorylation or chemiosmosis.

Limited responses

- Some wrote 'substrate-linked reaction' without specifying phosphorylation.
- Some answers were more general and did not focus on how exactly ATP is synthesised, such as 'aerobic and anaerobic respiration'.
- A few did not realise that a jellyfish is an animal and wrote photosynthesis or photophosphorylation.

(c)(i) Comprehensive responses

- Candidates read the figures from the correct line of Table 9.1 (respiratory substrate **B**) and divided the volume of carbon dioxide produced by the volume of oxygen used.
- They calculated $1430 \div 2020$ as 0.7079 or with more decimal places and rounded this answer to two significant figures as required (0.71).

Limited responses

- Some rounded their answer to 0.7 (1 significant figure) or 0.70 (incorrect rounding).
- Some divided the volume of oxygen used by the volume of carbon dioxide produced.

(ii) Comprehensive responses

- Most selected substrate **A**, where the volume of carbon dioxide produced equals the volume of oxygen used, giving an RQ of 1.

Limited responses

- A few candidates selected substrate **C**.
- Some candidates named a substrate rather than stating a letter from **Table 9.1** as instructed.

Question 10

(a) Comprehensive responses

- Candidates summarised genetic engineering as the changing of an organism's DNA so that it expresses a new protein and shows a different phenotype.
- Some mentioned inserting a new gene or allele to achieve this, and some mentioned gene editing as a form of genetic engineering where a gene could be deleted or replaced.

Limited responses

- Many wrote about how genetic engineering can be performed with reference to numerous enzymes and stages involving vectors, without covering the essential point of adding to or changing the DNA of a living *organism* so that its characteristics are changed.
- Responses that described events as far as the creation of recombinant DNA in a plasmid or vector did not establish the key context of changing the DNA of an organism.

(b)

Comprehensive responses

- Candidates named the faulty gene in severe combined immunodeficiency (SCID) as the ADA gene for adenosine deaminase (mentioned on the syllabus in learning outcome 19.2.1 in the context of recombinant therapeutic proteins).
- Candidates knew that the normal form of the gene should be expressed in T-lymphocytes to produce the functional enzyme adenosine deaminase.
- Candidates realised that this gene therapy does not occur by injecting an engineered vector into the body, as bone marrow stem cells have to be removed from the patient, engineered in vitro and then returned to the patient.
- Very comprehensive answers referred to the use of a drug to increase the number of stem cells in the bone marrow before extraction, or to chemotherapy or radiotherapy to remove faulty stem cells from the bone marrow at a later point to make room for the engineered, corrected cells.
- Terminology was used correctly and relevant details were specified.
- Answers covered all the necessary stages, e.g. preparation of the vector, obtaining and modifying the patient's cells, and then returning these cells to the patient.

Limited responses

- Candidates assumed an engineered vector could be injected into the body with the destination cells often not specified or referred to loosely as white blood cells or lymphocytes.
- CRISPR or processes leading to recombinant bacterial plasmids were described and there was an emphasis on the roles of different enzymes in altering DNA rather than a focus on patient treatment and physiology.
- Candidates did not appreciate that a permanent cure could be provided if blood stem cells were corrected rather than mature T-lymphocytes.
- Some candidates wrote about gene therapy to treat the eye disease Leber congenital amaurosis (LCA).

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Key messages

What candidates did well

- Many candidates demonstrated good knowledge and understanding of processes such as respiration, homeostasis, speciation and neurone physiology.
- Many candidates showed a good understanding of the format required for genetic crosses, such as in **5(a)**.
- Many candidates showed good application skills by successfully analysing the information given and then formulating a correct response, such as in **6(d)**.

What candidates needed to improve

- Candidates need to take note of the command word 'Outline' and avoid giving lots of unnecessary detail, such as in **1(b)**, **3(c)(i)**, **9(b)** and **10(a)**.
- Candidates would benefit from always being specific about which membrane they are describing, such as in **8(b)**.
- Candidates would benefit from stating the direction of movement of substances – both where the substance came from and where it goes, such as in **1(b)** and **8(b)**.
- Comparative statements are often required in answers, such as **4(c)**, **7(c)(i)**, **8(b)** and **9(a)**.
- Candidates need to take care to spell technical terms correctly, such as **(b)(i)**, **3(a)(ii)**, **7(b)**, **8(b)** and **9(b)**.
- Many candidates used the words 'bind to' and 'react with' or 'combine with' indiscriminately. For example, they might say that acetyl coenzyme A 'binds to' oxaloacetate to form citrate in **9(b)**.
- There was indiscriminate use of the terms 'activated', 'stimulated', 'released' and 'produced'. For example, they might say that cAMP is 'activated' or 'stimulated' by the binding of ADH to its receptors, rather than that it is 'produced' in **8(b)**.
- Candidates are encouraged to use only abbreviations that are in the syllabus. Abbreviations such as rNAD or redNAD are not a substitute for reduced NAD. If a candidate wants to use an abbreviation, they should use the full term at least once in their response.
- There was incorrect use of ATPase when ATP synthase was the correct term, such as in **10(a)**.

Comments on specific questions

Question 1

(a) Comprehensive responses

- Many candidates identified the structures associated with synapses, neuromuscular junctions and myelination correctly.
- Responses also showed a secure understanding of the structures responsible for saltatory conduction, with both nodes of Ranvier and the myelin sheath identified.
- Candidates who related the labelled structures to their functions throughout the neurone were able to answer all parts consistently.

Limited responses

- Some candidates may have confused structures located at opposite ends of the neurone, indicating uncertainty about the pathway of nerve impulse transmission. The position of the synapse was commonly confused with the position of the neuromuscular junction.
- Candidates would benefit from considering the direction of an impulse and the function of each labelled structure before selecting their responses.

- Candidates are advised to draw an arrow showing the direction of an impulse along a motor neurone to help with identification of neurone structures.
- Some candidates incorrectly identified the two structures required for saltatory conduction.

(b)(i) Comprehensive responses

- Many candidates described the sequence of events during an action potential in the correct order. Some candidates also included hyperpolarisation as part of the complete sequence of membrane potential changes.

Limited responses

- Some responses described the mechanisms responsible for establishing the resting potential rather than the events occurring during an action potential. These responses often included the incorrect direction of sodium ion and potassium ion movement.
- Some candidates confused the direction of sodium ion and potassium ion movement, including using the term influx incorrectly instead of efflux, for example, describing ions as undergoing an 'influx out of the neurone'.
- Some candidates referred to the axon or neurone itself as depolarising or repolarising without making clear that these changes occur across the cell surface membrane as a consequence of ion movement.
- Candidates would benefit from making a stronger link between ion movement and the resulting changes in membrane potential when describing an action potential.
- Many candidates needed to cover more than the depolarisation part of the action potential.
- Some candidates answered in the context of transmission of an action potential and not the events that occurred during one action potential.
- Some candidates presented their response in the context of synaptic transmission, including the behaviour of calcium ion movement.
- Some candidates mixed up active transport with ion movement through channels.
- Some candidates mixed up the repolarisation and hyperpolarisation phases of the action potential and used these terms interchangeably.

Question 2

(a) Comprehensive responses

- Many candidates correctly identified both structures on the barley seed diagram by the functions given. These responses showed clear understanding that gibberellin is released from the embryo and acts on cells in the aleurone layer to stimulate amylase synthesis, and of the physical locations of these structures.

Limited responses

- Some candidates needed to identify the aleurone layer more precisely.
- Where one structure was misidentified, this was more commonly the aleurone layer than the embryo.
- Some responses confused the labels on the diagram and identified the embryo as the endosperm.
- Candidates can improve by linking the role of each structure to the sequence of events in barley germination: gibberellin release from the embryo followed by amylase synthesis in the aleurone layer.

(b)(i) Comprehensive responses

- Many candidates correctly identified all three proteins in the gibberellin signalling pathway. These responses recognised the gibberellin receptor as the protein that gibberellin binds to in the aleurone layer, the DELLA protein transcriptional repressor as the protein that the gibberellin-receptor complex then binds to, and PIF (or transcription factor) as the protein that binds to DNA upon breakdown of DELLA.

Limited responses

- Some candidates needed to recognise that gibberellin binds to its cognate receptor. This was the protein most commonly omitted or misidentified.
- Some responses included imprecise spelling of syllabus terms, for example, writing DELTA instead of DELLA. Candidates should ensure that spelling of biological terms is clear enough to distinguish between different terms.

(ii) Comprehensive responses

- Most candidates identified the promoter as the region of DNA to which RNA polymerase binds.
- Many candidates also recognised that the gene product was amylase, or mRNA for amylase, following DELLA breakdown and binding of PIF to DNA.

Limited responses

- Some candidates stated only mRNA as the gene product. Candidates needed to make the answer more specific by referring to amylase, or mRNA for amylase, because the question was set in the context of the gene being switched on during barley seed germination.
- Some responses gave gene or DNA as the gene product. Candidates can improve by distinguishing between the gene as the DNA sequence and the proteinaceous product that results from expression of that gene.

(c) Comprehensive responses

- Almost all candidates correctly stated that the pea plants would be shorter or dwarf if active gibberellin was not produced. These responses linked the homozygous recessive genotype to the absence of active gibberellin and the resulting reduction in stem elongation.

Limited responses

- A few candidates described only the effect on stem elongation without clearly stating the phenotypic effect on plant height. Candidates needed to apply the information about active gibberellin to the visible phenotype of the plant.

Question 3

(a) (i) Comprehensive responses

- A small number of candidates provided responses that named up to three or four appropriate genetic techniques and outlined how each could be used to distinguish between DNA from the two separated tree-frog populations. These responses commonly included polymerase chain reaction (PCR) to amplify DNA, gel electrophoresis to compare or separate DNA fragments, and databases or bioinformatics to compare nucleotide sequences.
- Many candidates correctly linked PCR with amplification of DNA.
- Some responses also showed clear understanding that gel electrophoresis separates DNA fragments by length.

Limited responses

- Some candidates named appropriate techniques without giving further outline detail about what each technique would show. Candidates needed to outline the use of each technique, rather than give only a list of names.
- Some responses gave detailed descriptions of laboratory procedures without focusing on the instruction to outline techniques that could distinguish between the two DNA samples.
- Candidates can improve by matching each technique to its purpose in the context of comparing DNA.
- For gel electrophoresis, some candidates referred to separating DNA without specifying DNA fragments.
- For database comparisons, some candidates referred to comparing DNA without mentioning bases or nucleotides.
- For microarrays, some candidates described fluorescent probes without linking the technique to genome analysis or provided information about microarray uses not relevant to the DNA context, such as gene expression.
- Candidates can improve by remembering that amplification of DNA is often needed before further analysis can be carried out.

(ii) Comprehensive responses

- Comprehensive responses described allopatric speciation in a logical sequence. These responses usually began with geographical separation and no contact between the populations, then explained reproductive isolation or no gene flow, followed by different mutations, different selection pressures, the differences in characteristics that ensue, and eventual inability to interbreed to produce fertile offspring.
- Many candidates showed clear understanding that geographical separation between the two tree-frog populations could lead to genetic isolation and, over time, speciation.

Limited responses

- Some candidates needed to state that mutations and selection pressures were different in the separated populations. Responses that referred only to mutations or selection pressures without this comparison did not fully explain divergence between the populations.
- Some responses suggested that different selection pressures caused different mutations. Candidates can improve by separating these ideas: mutations arise, and selection pressures then affect which alleles become more common in each population.
- Fewer responses referred to named morphological, behavioural, ecological or niche differences, or explained that the populations could no longer interbreed to produce fertile offspring.
- Candidates should develop the full sequence from isolation to reproductive separation.

(iii) Comprehensive responses

- Many candidates interpreted the observations correctly and concluded that speciation had taken place in accordance with the biological species model.
- Comprehensive responses explained that reproductive barriers to successful interbreeding comprised the different mating calls showing behavioural isolation as a prezygotic isolating mechanism, and that mating between an S female and an N male did not produce offspring because fertilised eggs were not viable as a postzygotic isolating mechanism.

Limited responses

- Some candidates repeated the general stages of allopatric speciation from the previous part rather than using the observations in the contact zone.
- Candidates needed to state clearly what the observations showed about the current relationship between the two tree-frog populations. In some responses, it was unclear whether candidates thought speciation had already taken place or was still in progress.
- Candidates can improve by making a clear conclusion, then supporting it with the evidence from mating behaviour and offspring production.
- Some candidates referred to reproductive isolation without identifying behavioural isolation. Candidates should link the attraction to different mating calls directly to behavioural isolation.

(b) Comprehensive responses

- Many candidates recognised that body length variation in tree-frogs is influenced by both genetic and environmental factors. These responses often gave diet, food availability, nutrition, competition for food, temperature or disease as relevant environmental examples.
- Comprehensive responses also explained that many genes, or polygenes, are involved in continuous variation such as body length.

Limited responses

- Some candidates needed to distinguish between genes and alleles or mutations when describing genetic factors. Some responses referred to multiple alleles rather than many genes, which did not clearly explain continuous variation in body length.
- Some candidates described crossing over, independent assortment or other processes in meiosis. Some candidates also described evolutionary processes and disruptive selection between two populations causing differences in body lengths, instead of the variation within a species or population in the same generation. These responses needed to focus more directly on the current interaction between genetic and environmental factors in determining phenotype.

Question 4

(a) Comprehensive responses

- Many candidates recognised that genetic engineering is a targeted process used to produce crops with specific desirable characteristics.
- The most effective responses began with an overall description of genetic engineering before explaining how genetic material is modified to achieve the intended outcome.
- Many candidates used the terminology found in the syllabus to explain what genetic engineering is.

Limited responses

- Some responses described genetic engineering in very general terms by referring to changes in genetic information without identifying the level at which the modification takes place.
- Other responses focused on the outcomes of genetic engineering, such as improved crop yield or disease resistance, rather than explaining the process itself.
- Candidates would benefit from distinguishing between describing what genetic engineering is and why it is carried out, as these ideas were often combined into a single, less precise explanation.

(b) Comprehensive responses

- Many candidates interpreted the graphical data correctly and applied an appropriate method when calculating the percentage change. Responses that identified the correct starting value before beginning the calculation were generally accurate.

Limited responses

- Some responses showed that the method for calculating percentage change was understood, although the starting value was not consistently used as the reference point.
- Other responses included inaccuracies introduced when values were read from the graph.
- Candidates would benefit from identifying the quantity that represents the original value before carrying out percentage calculations based on graphical data.
- Candidates would benefit from reading the graph carefully using a ruler to produce an accurate figure.
- Some candidates divided the difference in values by the final value of 170.

(c) Comprehensive responses

- Many candidates used appropriate examples of genetically modified crops to explain how genetic modification can improve food supply.
- Responses commonly referred to increased productivity, improved crop quality and modifications that reduce losses during crop production.
- The most effective responses integrated these examples into a clear explanation of how genetic modification contributes to a more reliable food supply and recognised that improvements in agricultural efficiency can also provide wider economic benefits.

Limited responses

- Some responses presented examples of genetically modified characteristics with limited explanation of how these contribute to improvements in food supply.
- The terminology used to describe genetic modifications was not always precise, with some candidates referring to crops as being resistant to pesticides rather than resistant to insect pests or tolerant to herbicides.
- Economic advantages were also often described in general terms, such as crops being 'cheaper' or 'saving money', rather than explaining how increased productivity, reduced crop losses or more reliable harvests contribute to improved profitability and food production.
- Some candidates confused the outcomes of insect-resistant crops and herbicide-resistant crops by stating that the result would incorrectly mean less use of herbicides, giving an economic advantage.
- Candidates would benefit from using precise biological terminology and developing explanations that clearly link each example to its contribution to food supply.
- A small number of responses referred to genetically modified salmon rather than crop plants.

Question 5

(a) Comprehensive responses

- Most candidates correctly used the information provided to work out the genotypes of the two parents. They then wrote the gamete genotypes, offspring genotypes and their phenotypes into the table, thus performing the correct cross.

Limited responses

- Some candidates had difficulty in using the information about Z and W chromosomes and gave a genotype for the blue female that had two Z chromosomes.
- Some did not deduce the genotype of the male parent correctly.
- In general, candidates were able to write the gamete genotypes into the space provided in the table and also to deduce the genotypes of the offspring.
- Some candidates missed the inclusion of the sex in the phenotype as well as the feather colour, not recognising that this is a requirement of a sex-linked inheritance genetic diagram.
- Those candidates who had given incorrect genotypes for the parents missed the importance of not showing a brown female among the offspring.

(b) Comprehensive responses

- It was rare to see an answer that obtained both available marks. Some candidates correctly stated that the cross showed sex linkage, and a few also recognised that this was a situation where multiple alleles were involved.

Limited responses

- Many answers gave no correct response.
- Some did recognise that it was a monohybrid cross, which is not a type of inheritance and was not credited. Some also suggested it was a dihybrid cross.
- It was rare to see any mention of multiple alleles or a dominance hierarchy.
- Some incorrectly suggested epistasis or that the inheritance was both sex-linked and autosomal, which is a contradiction.
- A few candidates only suggested sex inheritance and not linkage.

(c) Comprehensive responses

- There were some clear descriptions in which the ash-red male pigeon would be mated with a brown female, followed by clear statements of how the offspring produced would enable determination of the genotype of this male parent. Genotypes were shown fully, for example $Z^A Z^{BI}$.

Limited responses

- Some candidates did not recognise that a test cross would be needed.
- Even where an attempt was made to describe a test cross, not all realised that the female would need to be chosen by her phenotype, not genotype.
- Descriptions of the way in which the colours of the offspring would be used to determine the genotype of the male parent were often not complete. For example, they might say that if some of the offspring were blue, this showed that the male parent was 'heterozygous dominant', which is not a clear statement about his genotype.
- A few candidates described crosses between two male pigeons.
- To improve their responses, candidates may benefit from spending some time annotating key words in the question stem.

Question 6

(a) Comprehensive responses

- The majority of candidates could name facilitated diffusion as the process by which glucose enters neurones.

Limited responses

- Some candidates opted for active transport or (simple) diffusion, and some named transport proteins such as 'cotransport proteins' or GLUT proteins.

(b) Comprehensive responses

- Most candidates gave the correct answer of 480 to this calculation.

Limited responses

- Sometimes candidates did not round correctly and gave an answer of 479. Those that did so usually included evidence of the correct division (4.7/9.8) in their working and therefore gained a working mark. This highlights the importance of showing working in calculation questions.

(c) Comprehensive responses

- Many responses included reference to sodium-potassium ion pumps and many followed this up with their role in maintaining resting potential.
- Candidates often explained how the movement of vesicles or exocytosis requires ATP and sometimes referred to the production of the neurotransmitter as an ATP-requiring process.
- Sometimes candidates qualified the impulses, synapses or action potentials as being numerous.

Limited responses

- While candidates often understood the high degree of processing that occurs in the brain, they frequently used incorrect terminology such as 'information' or 'signals' being transmitted or received, rather than action potentials or impulses.
- It was quite common for responses to suggest that the transmission of the impulse required ATP or that the brain has faster transmission of impulses, which requires more ATP.
- Occasionally candidates used the phrase 'exocytosis of vesicles', suggesting that the entire vesicle is released from the cell.
- Few candidates recognised that the setting up and maintenance of ionic gradients or the production of acetylcholinesterase required ATP.

(d) Comprehensive responses

- The vast majority of candidates used the information provided in the question very effectively and explained how the similar shape of the caffeine molecules meant that they could bind to the adenosine receptors and prevent adenosine from doing so.
- Many also explained how caffeine would not inhibit postsynaptic neurone activity and that this resulted in wakefulness.

Limited responses

- Sometimes candidates confused the adenosine receptors with enzymes and explained that caffeine blocks the active site.
- Candidates did not always use the information provided and commonly omitted reference to the postsynaptic activity continuing.

Question 7

(a) Comprehensive responses

- Most candidates were able to show their knowledge of classification to gain both marks.

Limited responses

- Some candidates could not link the binomial name of the damselfly given at the beginning of the question with the genus and species categories of the classification table.
- Some candidates put the class and family taxa in the incorrect order.

(b) Comprehensive responses

- Many candidates included the correct feature for both kingdoms and whether the feature was found or not, or what was found instead.
- Many candidates presented their response in a table which was clear and concise.
- Candidates who presented their response in table form often avoided the possibility of missing one of the comparative points.

Limited responses

- Some candidates only included the features that either Plantae or Animalia possessed, and did not write the converse for the other kingdom.
- Some candidates made spelling errors which led to a different meaning, for example, heterotropic instead of heterotrophic.
- Some candidates did not give enough specific detail. For example, 'Plantae have large vacuoles but Animalia don't' can be improved by adding a description of the type of vacuoles that Animalia have instead, such as small and temporary vacuoles. A common misconception was that Animalia have vesicles instead of vacuoles.
- Candidates would benefit from choosing one point of comparison with the detail for both kingdoms instead of a list of features for one kingdom followed by a list of features for the other kingdom. Often the features chosen for each kingdom did not match up for a comparative point for both kingdoms.

(c) (i) Comprehensive responses

- Comprehensive responses used language that contained the idea of change, such as more predators, loss of habitat, increased competition, thus using the context of the question to good effect.
- Candidates who did well used the bullet points of information in the question to structure their answers.
- Some also included the names of specific prey from the information given to enhance the context of predator-prey interactions.
- Candidates who gave the example of a new alien species and then linked this to the possibility of being a new competitor, new predator or the introduction of a new disease achieved three marks.

Limited responses

- Limited responses did not indicate an idea of change, so while many wrote about predators and competition, it was not in the context of there being an increase. Candidates should note that there is always competition and predator-prey interactions in food chains. For a species to become endangered, there must be a change to this balance of interactions.

(ii) Comprehensive responses

- Many candidate responses related the information given in the question to their knowledge of the mark-release-recapture method and often gained both marks for suggesting that migration and death before recapture would affect accuracy.

Limited responses

- The short life span of the damselfly was often cited as a source of inaccuracy, and to make this an improved response candidates needed to relate this to the chance of death between capture and recapture.
- Very few candidates linked the possibility of a small population to an inaccurate population estimation and often confused population size with sample size.

Question 8

(a) Comprehensive responses

- Most candidates could recall that sodium-potassium ion pumps are in the basolateral membrane (labelled P) and that cotransport proteins are in the luminal membrane (labelled S) of the proximal convoluted tubule cell. Almost all candidates knew that the structure labelled R (tight junction) prevents leakage of fluid.

Limited responses

- The majority of candidates only suggested one structure that glucose molecules pass through rather than both P and S, frequently omitting P.
- Candidates should read the question carefully; they were asked for 'structures' (plural), strongly suggesting more than one was required. It is worth noting that the question stated that each letter may be used once, more than once or not at all.
- Some candidates did not recognise that sodium-potassium ion pumps are found in the basal membrane labelled P, and that cotransport proteins are found in the luminal membrane labelled S, and these were often given the wrong way round.

- Candidates would benefit from taking time to analyse the diagram and even annotating it to recognise that the direction of movement of substances is from the lumen to the blood, from the left of the diagram to the right.

(b) Comprehensive responses

- Many candidates could describe the role of ADH in osmoregulation in accurate detail and scored very well on this question. They could state the precise location of the ADH receptors on the cell surface membrane of collecting duct cells and could often give excellent descriptions of events inside the cell.
- Most understood the significance of cAMP production and the subsequent events involving the enzyme cascade and mobilisation of the vesicles.
- Most candidates could explain how cell membranes of the collecting duct became more permeable to water as a result of aquaporins being added and that water could then move from the filtrate into the blood by osmosis, producing more concentrated urine. There was a good use of the terms 'volume' and 'concentration' when referring to urine production.

Limited responses

- Candidates were given an extended response question which asked them to describe the role of ADH after a decrease in water potential was detected in the blood by osmoreceptors. Many did not make good use of their time by repeating much of the introduction to the question.
- Candidates rarely stated that a decrease in water potential of the blood causes an increase in the release of ADH. Instead, the common response was that it is simply released. The comparative is necessary as a consequence of the change in blood water potential.
- Some candidates either omitted that the pituitary gland was the posterior part or did not spell the name of the gland correctly.
- It was quite common for candidates to describe the location of ADH receptors as being in the cell membranes of collecting duct cells, rather than the cell surface membrane, and this error was frequently repeated when describing how the vesicles with aquaporins fuse and where the aquaporins are added.
- Quite often candidates described cAMP as being activated or even released, when it is made from ATP.
- Candidates would benefit from describing vesicles as fusing with the cell surface membrane rather than binding to it.
- Very few candidates highlighted that more aquaporins are added to the cell surface membrane of collecting duct cells. The comparative statement is vital to show clear understanding of the role of ADH.
- Some candidates did not give a comparative response for the change in membrane permeability by stating it became permeable, implying that a membrane is normally impermeable to water.
- A significant minority of candidates, when explaining the movement of water by osmosis, qualified this with water moving down a concentration gradient instead of a water potential gradient.

Question 9

(a) Comprehensive responses

- Many candidates described how glycolysis would be affected by the production of less hexokinase, for example, 'less ATP formed'.
- Candidates included most of the relevant aspects of glycolysis that would be affected by the production of less hexokinase.
- Many candidates described a consequence of less hexokinase on oxygen availability, for example, 'loss of red blood cells'.
- Most candidates suggested a symptom for a person with hexokinase deficiency disease, for example, 'fatigue' or difficulties related to breathing.

Limited responses

- Some candidates suggested the production of less hexokinase would stop or slow down events related to glycolysis, for example, 'no pyruvate produced'.
- Some candidates suggested effects that did not focus on glycolysis, for example, haemoglobin not binding with oxygen.
- A significant minority of candidates incorrectly stated that sickle cell anaemia would be caused.
- Some responses did not contain sufficient detail, for example, 'low rate of respiration because the enzyme is missing'.

(b) Comprehensive responses

- Most candidates gave a clear outline of the main stages in the Krebs cycle, including appropriate scientific terms spelt correctly.
- Many candidates correctly described how acetate combines with oxaloacetate to form citrate.

Limited responses

- A common misconception is that 'acetyl' combines with oxaloacetate. There are a number of correct options: acetyl coenzyme A, acetate, an acetyl group or a 2C fragment.
- Some candidates missed key elements of the Krebs cycle, for example, decarboxylation or regeneration of oxaloacetate.
- Some candidates correctly stated that reduced NAD is formed and then incorrectly wrote that FAD is also formed.
- Many candidates outlined the production of ATP and very few linked this to substrate-linked phosphorylation.
- A few candidates named several intermediates produced during the Krebs cycle that are not relevant in an outline. Most intermediates between citrate and regeneration of oxaloacetate do not need to be named for this syllabus.
- A small number of candidates would benefit from being more precise with the spelling of oxaloacetate.

(c) Comprehensive responses

- Comprehensive responses gave a clear description of anaerobic respiration in muscle cells using correct terminology spelt correctly.
- Most candidates included reference to lactate and lactate dehydrogenase.
- Some candidates realised the significance of pyruvate reduction in the regeneration of NAD.

Limited responses

- Some candidates wrote lactose instead of lactate.
- A few candidates referred to anaerobic respiration in yeast or plants instead of in muscle cells.
- A few candidates focussed on the absence of oxygen or limited production of ATP instead of describing the process.

Question 10

(a) Comprehensive responses

- Many candidates named structures in a chloroplast logically linked to a specific function in photosynthesis.
- Many candidates distinguished between the functions of DNA and ribosomes in protein synthesis.

Limited responses

- Some candidates wrote in great detail about a particular aspect of photosynthesis which is not required for an 'Outline' command.
- Many candidates gave detailed descriptions of the processes that occur in photosynthesis and did not go on to link the part of the process to the structure where it occurs. For example, there were some detailed descriptions of creating a proton gradient and these were not linked to the thylakoid space. A table or list format response was uncommon and this would have been a good way of structuring an answer.
- There were many references to 'thylakoids' rather than thylakoid membranes, which were named in Figure 10.1.

- A common answer was that DNA was present to synthesise proteins instead of to code for proteins.

(b)(i) Comprehensive responses

- Many candidates correctly determined the R_f for pigment B on Figure 10.2.
- Most candidates gave their answer to two decimal places, matching the example R_f for pigment A given in the question.

Limited responses

- Many candidates measured from 0 cm on the chromatography paper rather than from the baseline, which gave an incorrect value of 0.5.

(ii) Comprehensive responses

- The vast majority of candidates had a value of 0.42 or 0.5 from their calculation in **Question 10(b)(ii)**. Both answers would identify the same pigment in Table 10.1.
- Most candidates correctly identified the two pigments from the table.

Limited responses

- A few candidates had Pigment A and Pigment B the wrong way around.

(iii) Comprehensive responses

- Many candidates correctly stated that Pigment A and Pigment B were accessory pigments.
- Most candidates referred to the pigments absorbing light and some correctly stated that the energy was passed on to the reaction centre.

Limited responses

- Few candidates stated that the range of wavelengths absorbed was extended.
- A significant minority of candidates recognised that the given pigments absorbed different wavelengths of light and did not go on to state what they were different from, for example, the primary pigment.
- Some candidates incorrectly wrote about frequencies of light.
- Occasionally candidates described chlorophyll B as a primary pigment and carotene as an accessory pigment.

BIOLOGY

Paper 9700/43 A Level Structured Questions

Key messages

What candidates did well

- Candidates often used the information provided effectively and could apply it well to the question.
- Many candidates showed strengths in the ecology topics and could apply their own knowledge to the novel situations.
- Candidate responses frequently showed very good knowledge of key processes such as cell division, ultrafiltration and completion of genetic crosses.

What candidates needed to improve

- Recurrent errors throughout this paper included calling ATP synthase ATPase, which contradicted the expected terminology.
- Some candidates wrote about energy being produced, which was incorrect.
- Candidates could often improve on their responses to biochemistry questions, which usually demand the naming of reactions, processes and molecules rather than vague descriptions.
- Examples of key processes include phosphorylation, reduction and oxidation reactions, active transport, diffusion and those involved in blood glucose control.
- Examples of molecules requiring accurate naming include fructose biphosphate, triose phosphate and ribulose biphosphate.

Comments on specific questions

Section A

Question 1

(a) Comprehensive responses

- The vast majority of candidates were able to identify all structures on the diagram of a neuromuscular junction correctly.

Limited responses

- The most common error was to identify **B** (the presynaptic neurone) as the structure which contained a neurotransmitter rather than **F**, the vesicle.

(b) Comprehensive responses

- Many responses showed detailed knowledge of the endocrine system, especially its involvement in the control of blood glucose concentrations, and linked the production of glucagon to the subsequent increase in blood glucose concentration.

Limited responses

- Some candidates could have improved their answer by referring to a range of hormones rather than one.
- Many candidates only addressed water loss through sweating as a response to running and only sometimes explained how ADH was involved in reducing this.
- Some candidates confused insulin with glucagon and stated that 'glucagon is released from beta cells', and some confused secretion from the pancreas with the hypothalamus.
- Candidates can improve by learning the correct spellings for key terms such as glycogenolysis and gluconeogenesis.

Question 2

(a) Comprehensive responses

- Many candidates could identify the correct meiotic stages from the images in Figure 2.1.

Limited responses

- Errors were usually in the naming of the stage in cell B, with anaphase or telophase II being suggested quite frequently.
- Candidates would benefit from appreciating that meiosis has two divisions and therefore it is essential to state 'I' or 'II' in addition to the name of a stage.
- Some candidates gave 'interphase' as their response, and this is not a stage of meiosis or mitosis.

(b) Comprehensive responses

- Some candidates provided very concise and accurate responses to explain the meaning of a homologous pair of chromosomes by clearly describing homologous chromosomes in terms of their size and position of gene loci.

Limited responses

- Many candidate responses showed misconceptions and confusion around the use of key terms. Rather than explaining what a homologous pair of chromosomes is, many described sister chromatids being joined at the centromere and being genetically identical.
- Many candidates did not refer to homologous chromosomes as having the same genes and instead referred to the same alleles. Instead of stating that the chromosomes have the same gene loci, they described the loci as being similar.
- Candidates would benefit from avoiding the statement that the chromosomes 'code for the same gene' and appreciating that genes do not 'code for' the genetic code; rather, the genetic code determines the amino acid sequence of proteins.

(c) Comprehensive responses

- Many candidate responses used clear statements and showed correct use of key terms such as haploid, diploid, gametes and zygote, and understood that chromosome number would double without reduction division.

Limited responses

- A significant number of candidates focussed on the term 'meiosis', rather than 'reduction division', and in doing so described genetic variation, crossing over and independent assortment, which were not relevant.

Question 3

(a) Comprehensive responses

- A relatively small proportion of candidates provided an accurate outline of the steps involved in PCR. They stated denaturation, annealing and elongation as the main steps and qualified these terms with appropriate detail.

Limited responses

- Few candidates were able to effectively express the idea that primers would be designed to be specific to the mutant *HBB* allele.
- Of the candidates who stated that primers would be specific, many were not clear that they would be specific to the mutant allele rather than the normal allele.
- A common error was the use of restriction enzymes to select the correct DNA fragment for amplification, and this error was evident even in comprehensive responses.
- Many candidate responses did not contain sufficient accurate detail or contained errors, for example, stating that 'denaturing occurred' with no reference to 'DNA', that Taq polymerase started 'transcription' instead of DNA replication or that 'annealing occurred' with no reference to 'primers'.
- Confusion also included references to RNA primers, ligase, denaturing hydrogen bonds and denaturing involving the breaking of phosphodiester bonds.

(b) Comprehensive responses

- Most candidates could identify the correct person according to the description of genotype given.

Limited responses

- Some candidates made an error with the last person, where only one person was identified as having a heterozygous genotype rather than the two people required.

(c) Comprehensive responses

- Some candidates appreciated the importance of adding the fluorescent label to the sample of DNA. They stated that the microarray consists of probes of the *HBB* allele and that the single-stranded sample DNA will bind to the probes if the allele is present.
- Some could also explain how fluorescence indicates the presence of the *HBB* allele.

Limited responses

- Most candidate responses showed considerable confusion about the use of a microarray, with many focusing on the version for gene expression involving mRNA and cDNA rather than the analysis of the genome for the presence of a specific allele.
- Many candidates did not use the term 'probe' and instead used 'ssDNA', which was easy to confuse with the test ssDNA.
- Candidate responses frequently referred to different colours rather than fluorescence and described adding the fluorescent label to the probe rather than the sample DNA.
- Some candidates confused the process with genetic engineering and added marker genes to the sample DNA rather than the fluorescent label or dye.
- Some candidates confused the use of microarrays with electrophoresis and described the movement of DNA fragments.
- This question was quite often omitted.

Question 4

(a) Comprehensive responses

- Some candidates used the information provided in the question effectively and understood that 11 per cent of the population showing the black, recessive phenotype is represented by q^2 in the equation.
- These candidates could usually convert the value of q^2 to a decimal, calculate its square root and therefore find the value of q .
- Candidates could usually subtract the value of q from 1 to calculate the value of p and most knew to complete the calculation by calculating $2pq$.

Limited responses

- Many candidate responses did not show working for the series of calculations required to find the percentage of heterozygous leopards, which was required to achieve all marking points.
- The most common incorrect answer was 20% and this was usually the result of stating that q was 0.11 rather than calculating the square root, which candidates then used to calculate an incorrect value for p of 0.89.
- When asked to show working, candidates should write down the steps involved in a calculation as this is usually required to achieve all marking points.
- Candidates should avoid prematurely rounding to ensure an accurate answer.

(b) Comprehensive responses

- Some candidates provided concise answers which focussed on the genetic aspects of continuous and discontinuous variation and often explained that continuous variation has a polygenic basis.

Limited responses

- Responses frequently included irrelevant descriptions of the pattern of data produced by continuous and discontinuous variation and the role of the environment, rather than focussing on their genetic basis.
- Many candidate responses did not clearly describe the role of one or two genes versus many genes and rarely explained the additive effect of genes or the small effect of different alleles in continuous variation.

(c) Comprehensive responses

- Many candidates realised that the different populations experienced different selection pressures or environments and a small number of candidates linked selection to a different change in allele frequencies between the populations.
- Genetic drift or the founder effect were often referenced, and some candidates appreciated the lack of gene flow between populations.

Limited responses

- Candidates often suggested that allopatric speciation had occurred, despite being told that the leopards are the same species.
- Species, rather than the populations, were often described as being geographically isolated.
- Few candidates recognised that, because mutations are random, the different populations would have different mutations.

Question 5

(a) Comprehensive responses

- Sometimes candidates used the term phenotype in their explanations and could correctly define the term.

Limited responses

- Many candidate responses used the expression 'expressed in the phenotype' to mean that the trait is observable, although this is confusing language.
- Candidates would benefit from appreciating that it is genes or alleles that are expressed and that the proteins produced will have an effect on the phenotype.
- Candidates could improve responses by realising that expression (nearly) always happens for both dominant and recessive alleles, but only when both alleles are recessive will it be possible to observe this effect in the phenotype.
- Candidates would benefit from knowing that codominance is only relevant in the heterozygote, that there is no dominant allele and that it is incorrect to say both alleles are dominant, rather than that expression of both alleles is seen in the phenotype.

(b) Comprehensive responses

- Most candidates could correctly list the genotypes of each blood group.

Limited responses

- Occasionally candidates misunderstood the term 'genotype' and used terms such as dominant or recessive or only provided one allele for each genotype.

(c) Comprehensive responses

- Many candidate responses provided correct parental gametes and offspring genotypes.

Limited responses

- A few candidates were confused by the mix of symbols for the blood group and Rhesus factor alleles and omitted the I gene or did not use the symbols given.
- The most common error was to exclude the offspring phenotypes, although many still gave the correct ratio.

Question 6

(a) Comprehensive responses

- Candidates could often describe the process of ultrafiltration in some detail and were able to name the structures involved and describe their various adaptations.
- Many candidate responses explained how high pressure is achieved in the glomerulus by the afferent and efferent arterioles.

Limited responses

- Only a minority of candidates appreciated that the high hydrostatic pressure *forced* fluid into the Bowman's capsule.
- Some responses would have benefitted from more accurate detail throughout, for example by qualifying the high pressure in the glomerulus as blood or hydrostatic pressure and saying that fluid goes through gaps between the endothelial cells as it makes its way into the Bowman's capsule.
- It was not uncommon for candidates to say that blood moves into the Bowman's capsule.
- It was not unusual for candidates to describe red blood cells as large molecules which are unable to pass through the basement membrane.
- A few candidates misunderstood the question and wrote about the process of selective reabsorption.

(b) Comprehensive responses

- Some candidates explained how caffeine could bind to the ADH receptors and prevent ADH from doing so, and many could explain the reduction in water reabsorption as a result of fewer aquaporins being present in the collecting duct cell membranes.

Limited responses

- Candidates commonly suggested that caffeine stopped the release of ADH rather than reducing it.
- A few candidates suggested that caffeine itself alters the water potential of blood or lowers the water potential of the filtrate in the collecting duct.

Question 7

(a) Comprehensive responses

- The majority of candidates seemed well prepared to answer questions about species becoming endangered and most applied their knowledge to the example of lemurs in Madagascar very well.
- Many candidates recognised that a change was required, such as increased competition for food rather than simply a lack of food, a new disease rather than disease in general, or increased predation rather than predation in general.

Limited responses

- Some candidates simply stated factors such as a lack of food, predation and disease without suggesting that it is a *change* in these factors that has caused the lemurs to become endangered.

(b) Comprehensive responses

- Many candidates described IVF in detail and gave full accounts which included reference to hormones stimulating ovulation and the transfer of embryos produced in a laboratory to surrogate mothers.

Limited responses

- A significant number of candidates suggested that capturing lemurs and putting them together in a safe enclosure with plenty of food could be a method of assisted reproduction.
- Some candidates described how the egg or zygote is inserted into the surrogate, and many omitted the detail that it is inserted into the uterus.
- Some candidates misunderstood artificial insemination and suggested that sperm are inserted into eggs during this process.

(c) (i) Comprehensive responses

- Most candidates provided the correct working and followed the instruction to give their answer to the nearest whole number.

Limited responses

- Incorrect answers were usually due to a rounding error.

(ii) Comprehensive responses

- Many candidates showed a good understanding of the principles of the mark-release-recapture method and could apply at least some of them to the hissing cockroach scenario.
- Many candidate responses linked the information provided about their size and being flightless to the relative ease of marking and unlikely migration.
- Candidates sometimes commented on their mobility and related this to their ability to mix with the population following the first capture.

Limited responses

- Occasionally candidates explained why sampling in general is used rather than the suitability of this particular method for these particular organisms.

Question 8

(a) Comprehensive responses

- Some candidates had good knowledge of the functions of parts of a seed, especially the role of the aleurone layer and the endosperm.

Limited responses

- It was fairly common for candidates to mistake the seed coat for the location of maltose production.

(b)(i) Comprehensive responses

- Most candidates correctly identified hydrogen ions as the particles moving into the cell during event **A**, and many commented on the resulting decrease in pH and activation of expansins.

Limited responses

- Many candidates did not realise that the movement of hydrogen ions was by active transport and instead used terms such as influx, diffusion, release or even active diffusion to explain how they entered.
- A few candidates suggested that movement of the hydrogen ions was due to the channels pumping them in.
- Many candidate responses described a weakening of microfibrils rather than their loosening, to allow the elongation of the cell.

(ii) Comprehensive responses

- Many candidates explained that water entering the cell by osmosis was the result of ions, glucose or various solutes entering the cell, and some knew that this was due to the movement of potassium ions into the cell.
- Many went on to explain that the influx of water by osmosis would cause the cell to expand.

Limited responses

- Some responses simply repeated the information given in the question and said the cell elongated rather than explaining how.
- Many candidates did not appreciate that plant cells are always turgid and that the influx of water would increase this.
- A fairly common error was to describe the movement of water down a concentration gradient, rather than a water potential gradient.

Question 9

(a) Comprehensive responses

- Many candidates were secure in their knowledge of the function of the matrix, and many mentioned the folding of the inner membrane to increase surface area. Some also stated this as the location of oxidative phosphorylation or chemiosmosis.
- Occasionally candidates commented on the permeability of the outer membrane.

Limited responses

- Sometimes it was incorrectly stated that the outer membrane is permeable to allow glucose to enter.
- Candidates often mixed up the direction in which protons move, therefore confusing accumulation of protons in the matrix with accumulation in the intermembrane space.
- DNA is a code for proteins, but responses frequently stated that it is for producing proteins, which candidates should realise is the role of ribosomes.

(b) Comprehensive responses

- A minority of responses described how heart muscle cells contract and therefore require a lot of ATP, and on rare occasions they explained how red blood cells require space for haemoglobin.

Limited responses

- Candidates rarely commented on the trend shown in the data, with more active cells having more mitochondria.
- Although they did appreciate that heart cells are more active than the other cells, candidates frequently described their activity as pumping or moving rather than contracting, and often missed the link between the abundance of mitochondria and the production of a lot of ATP.
- Candidates usually described liver cells in terms of what they do not do (move) rather than what they do, only very rarely giving examples of activities such as glycogenesis to explain their need for some ATP.
- Responses often showed a misunderstanding of red blood cell structure and function, making statements such as less ATP being needed due to not having mitochondria or a nucleus, and some explained their absence of ATP as being due to their movement by diffusion or the idea of them flowing in the blood.
- Candidates who did come close to a correct explanation rarely referred to space for haemoglobin, instead referring to a lack of mitochondria allowing for more space for oxygen alone.

(c) Comprehensive responses

- Candidates succinctly explained how fructose biphosphate is split into two molecules of triose phosphate, which are then oxidised to produce pyruvate, and that ATP is produced.

Limited responses

- Many responses to this question used vague statements such as molecules being 'converted' rather than naming the specific process involved, such as phosphorylation or oxidation. A lack of precision in naming the molecules involved was also evident, often referring to six- or three-carbon molecules rather than fructose biphosphate or triose phosphate.

Question 10

(a) Comprehensive responses

- Candidates usually began their response with a statement about electrons being emitted or excited and proceeded to explain what happens to the electrons, often involving their movement along the ETC.
- Some candidates explained how protons are pumped into the thylakoid space using energy released from the ETC and how ATP is subsequently synthesised.

Limited responses

- Candidates often omitted reference to the release of energy as electrons move along the ETC and its use in the pumping of protons, instead describing the production of ATP without the necessary detail.
- Those who did describe protons being pumped using the energy released often did not specify their destination and, similarly, when describing their movement through ATP synthase, did not say they were destined for the stroma.

(b)(i) Comprehensive responses

- Most candidates could name triose phosphate as a compound formed during the Calvin cycle.

Limited responses

- Some candidates missed the instruction to name rather than use abbreviations, with RuBP being the most common error in this regard.
- Rubisco, glucose and carbon dioxide were fairly common incorrect answers, and phonetic spelling was an issue for some responses, with 'rubilose' being a frequent example.

(ii) Comprehensive responses

- Many candidates could state the conversion of GP to TP and some could name the reaction as reduction.

Limited responses

- Many described a loss of electrons or hydrogen rather than using the term oxidation of reduced NADP.

(iii) Comprehensive responses

- A small number of candidates could name an amino acid as the molecule produced.

Limited responses

- The most common incorrect answer given to this question was glucose, and sometimes triose phosphate.

(c)(i) Comprehensive responses

- A small number of candidates recognised this as a graph showing how limiting factors affect the rate of photosynthesis, and they usually suggested a suitable alternative limiting factor at high carbon dioxide concentrations.

Limited responses

- Many candidates approached this question from the perspective of an enzyme-controlled reaction and explained the relationship in terms of the rate of reaction being dependent on substrate concentration, often using the explanation that rubisco active sites are occupied as the graph plateaus.
- Frequently candidates described the graph rather than offering an explanation.
- Candidates who explained the graph in terms of limiting factors sometimes omitted the term 'concentration' when referring to carbon dioxide being the limiting factor at the beginning.

BIOLOGY

Paper 9700/44 A Level Structured Questions

Key messages

What candidates did well

- Candidates demonstrated secure knowledge and understanding across a broad range of biological topics, particularly molecular biology, respiration, ecology and genetics.
- Many candidates interpreted data successfully, identifying trends and supporting their answers with appropriate evidence and calculations.
- Strong responses used precise biological terminology, particularly in questions on PCR, respiration, photosynthesis and the lac operon.
- Many candidates constructed logical extended explanations when describing biological processes, including glycolysis, photosynthesis and speciation.
- Candidates generally performed well on familiar practical techniques and routine calculations.
- Higher attaining candidates successfully applied biological knowledge to unfamiliar contexts and linked biological processes in a logical sequence.

What candidates needed to improve

- Responses needed to remain focused on the context of the question rather than reproducing memorised biological information.
- Greater precision was needed when using biological terminology, particularly when distinguishing between related terms such as neurone and nerve cell, nitrogen and nitrate ions, species and organism, and operator and promoter.
- Explanations often required further development by linking biological cause and effect rather than describing observations alone.
- Candidates should support descriptions of trends with appropriate data and units where required.
- Sequential biological processes, including glycolysis, PCR, co-transport and lac operon regulation, should be described in a complete and logical order.
- Candidates should identify precise cellular and tissue locations when describing biological processes.

Comments on specific questions

Question 1

(a) Comprehensive responses

- Most candidates correctly identified the operator region of the lac operon.

Limited responses

- A significant minority did not provide an answer.
- Some candidates labelled another part of the operon instead.

(b) Comprehensive responses

- Few candidates named both gene products and accurately described their functions.
- Better responses recognised that lactose permease transports lactose into the cell and that β -galactosidase hydrolyses lactose.

Limited responses

- Many candidates named only one gene product.
- A common error was to identify the product of *lacY* simply as permease rather than lactose permease.

- Some candidates referred to lactose becoming permeable or to cells becoming permeable, indicating an incomplete understanding of the role of lactose permease.

(c) Comprehensive responses

- Candidates correctly described an inducible enzyme as one that is produced only when its substrate or inducer is present.

Limited responses

- Some candidates confused an inducible enzyme with the induced-fit model of enzyme action.

(d) Comprehensive responses

- Most candidates correctly interpreted the graph and recognised that glucose was used as the initial respiratory substrate.
- Many responses explained that, once glucose had been depleted, lactose entered the bacterial cells, the **lac operon** was activated and enzymes required for lactose metabolism were produced.
- Stronger responses explained that lactose was hydrolysed into its monosaccharides, which were then used in respiration, providing energy for cell division and resulting in an increase in the bacterial population.

Limited responses

- Some candidates recognised that the population remained constant after glucose had been depleted but did not explain that cell division had temporarily ceased.
- Some responses did not explain how the lac operon was activated or omitted reference to enzyme production.
- A common error was to state that lactose was used directly in respiration rather than first being hydrolysed.
- Some candidates omitted that the increase in population was due to bacterial replication (cell division).

Question 2

(a) Comprehensive responses

- Most candidates correctly identified the ions involved and their movements in each biological context.
- Many responses recognised that potassium ions enter guard cells and that calcium ions bind to troponin during muscle contraction.
- Stronger responses explained that sodium ions entering the presynaptic membrane cause depolarisation, followed by calcium ion entry which stimulates synaptic vesicles to fuse with the presynaptic membrane and release neurotransmitter by exocytosis.

Limited responses

- Some responses stated that potassium ions left the guard cells.
- Some candidates referred to depolarisation of the neurone or axon rather than depolarisation of the membrane.
- A common error was to state that synaptic vesicles were released by exocytosis rather than the neurotransmitter they contained.
- A few responses omitted the role of calcium ions in stimulating vesicle fusion.

(b) Comprehensive responses

- Many candidates correctly described the sequence of events involved in glucose reabsorption in the proximal convoluted tubule.
- Better responses explained that sodium ions are actively transported out of epithelial cells, lowering the sodium ion concentration within the cells and establishing a concentration gradient.
- Many recognised that sodium ions enter the cells from the lumen by cotransport with glucose before glucose diffuses into the blood.

Limited responses

- Some candidates identified the incorrect region of the nephron.
- Some responses omitted the movement of sodium ions from the lumen into epithelial cells.

- A few responses described active transport of glucose throughout the process.
- Few candidates recognised that glucose accumulates within epithelial cells before moving into the blood.

Question 3

(a) Comprehensive responses

- Most candidates identified a range of factors associated with human arrival, including habitat loss, hunting, pollution, climate change and the introduction of alien species.
- Many responses correctly linked introduced species with increased competition, predation or disease.

Limited responses

- Some responses referred generally to reduced resources without identifying the factors responsible.
- Some candidates described bottleneck effects or natural selection rather than the direct impacts of human arrival.
- A few responses lacked sufficient detail to distinguish between different causes.

(b) Comprehensive responses

- Most candidates calculated the population estimate correctly.
- Many responses correctly gave their answer to the nearest whole number.

Limited responses

- A small number of candidates did not round their answer to the nearest whole number.

(c) Comprehensive responses

- Many candidates explained that a reduction in body temperature decreases the kinetic energy of respiratory enzymes and substrates.
- Better responses linked this to fewer successful collisions, fewer enzyme–substrate complexes and a reduced rate of respiration.
- Some responses also recognised that diffusion of respiratory metabolites would occur more slowly at lower temperatures.

Limited responses

- Some candidates simply stated that respiration or enzyme activity decreased without further explanation.
- Some referred to fewer enzyme–substrate complexes without explaining the underlying cause.
- Few candidates identified specific respiratory metabolites when discussing diffusion.

(d) Comprehensive responses

- Many candidates correctly identified characteristics of members of the kingdom Animalia.
- Better responses described animals as multicellular, eukaryotic, heterotrophic organisms capable of movement and possessing nervous coordination.

Limited responses

- Some responses described general features of eukaryotic cells rather than characteristics of the kingdom Animalia.
- Some candidates referred only to the absence of cell walls or chloroplasts.
- A few incorrectly stated that animals possess chloroplasts or carry out photosynthesis.

Question 4

(a) Comprehensive responses

- Many candidates gave a logical description of allopatric speciation.
- Better responses explained that geographical isolation prevents gene flow between populations.
- Many recognised that different selection pressures and mutations result in changes to allele frequencies and gene pools, eventually leading to reproductive isolation and the production of separate species.

Limited responses

- Some candidates referred to *allotropic* speciation or used incorrect terms such as geometrical or geological isolation.
- Some responses described species rather than populations becoming isolated.
- A common misconception was that different environments directly caused mutations.
- Some candidates omitted the role of reproductive isolation.

(b) Comprehensive responses

- Some candidates accurately defined an ecosystem as the interaction between a community and both the biotic and abiotic components of the environment.
- Better responses defined a niche as the role of a species within an ecosystem.

Limited responses

- Many responses included relevant biological terms but did not construct complete definitions.
- Some referred to organisms rather than species or populations.
- Some omitted either the biotic or abiotic component of an ecosystem.
- A common error was to define a niche as the role of an individual organism.

Question 5

(a) (i) Comprehensive responses

- Most candidates calculated the percentage increase correctly.
- Many responses correctly multiplied the calculated value by 100 to express the answer as a percentage.

Limited responses

- The most common error was failing to multiply the calculated value by 100.

(ii) Comprehensive responses

- Many candidates explained that insulin binds to receptors on the surface membrane of liver or muscle cells.
- Better responses recognised that insulin stimulates insertion of additional GLUT transport proteins into the cell surface membrane of muscle cells, increasing glucose uptake.
- Many correctly stated that glucose is subsequently used in respiration or converted to glycogen, reducing blood glucose concentration.

Limited responses

- Some responses omitted the location of the insulin receptors.
- Some referred to GLUT proteins without explaining that additional transport proteins are inserted into the membrane.
- A few responses included unnecessary descriptions of unrelated hormonal regulation.

(b) (i) Comprehensive responses

- Many candidates correctly identified both enzymes.

Limited responses

- Some responses identified only one enzyme.
- A common incorrect answer was hydrogen peroxide or hydrogen peroxidase.

(ii) Comprehensive responses

- Many candidates recognised that recombinant human insulin has the same amino acid sequence and tertiary structure as naturally occurring human insulin.
- Better responses explained that this reduces the likelihood of an immune response or allergic reaction.

Limited responses

- Many responses focused on production advantages such as lower cost, greater yield or fewer ethical concerns rather than the significance of the identical amino acid sequence.
- A few responses referred to a reduction in disease transmission rather than complete prevention.

Question 6

(a) Comprehensive responses

- Most candidates correctly identified the required structures.
- Many responses demonstrated a secure understanding of the diagram and gained full credit.

Limited responses

- A small number of candidates incorrectly identified one or more structures or omitted a response.

(b)(i) Comprehensive responses

- Most candidates completed the table correctly.
- Many responses correctly calculated the relative light intensity and time values.
- Better responses presented calculated values using an appropriate and consistent number of decimal places.

Limited responses

- Some responses used an inconsistent number of decimal places.
- A few candidates made calculation errors when determining the relative light intensity.

(ii) Comprehensive responses

- Many candidates correctly described how increasing light intensity increased the rate of photosynthesis.
- Better responses supported descriptions with appropriate data and units.
- Some candidates explained that oxygen produced during photosynthesis accumulated within the leaf discs, reducing their density and allowing them to rise to the surface more rapidly.

Limited responses

- Some candidates described the relationship in terms of distance from the lamp rather than light intensity.
- Some described the trend as decreasing because the time taken became shorter.
- A number of candidates omitted supporting data or stated that oxygen reduced the mass rather than the density of the leaf discs.
- Some responses identified the trend without explaining the biological reason.

(iii) Comprehensive responses

- Many candidates correctly identified that light was no longer the limiting factor.
- Better responses recognised that another factor, such as carbon dioxide concentration or temperature, became limiting.

Limited responses

- Some candidates did not refer to limiting factors.
- A common misconception was that two identical lamps at the same distance would produce the same light intensity as a single lamp.

Question 7

(a) Comprehensive responses

- Many candidates used appropriate allele symbols and completed the genetic cross correctly.
- Better responses used the same letter in upper- and lower-case form, provided a clear key and recognised that NF1 is caused by a dominant autosomal allele.

Limited responses

- Some candidates did not use the term *allele* when defining the symbols used.
- Some responses treated NF1 as a recessive condition.
- Others completed the cross as though the condition were sex-linked.

(b) Comprehensive responses

- Many candidates discussed a range of social and ethical considerations associated with predictive genetic testing.
- Better responses referred to reduced anxiety following a negative result, opportunities for future planning, earlier treatment, informed reproductive decisions and psychological support.
- Some candidates also considered issues of confidentiality, discrimination and false positive results.

Limited responses

- Some responses lacked sufficient development of ethical issues.
- Privacy and potential discrimination were discussed less frequently.
- Some candidates described genetic screening in general rather than the specific implications of predictive testing.

(c) Comprehensive responses

- Many candidates correctly explained how an auditory tumour could disrupt transmission of nerve impulses.
- Better responses referred to failure of sodium ion channels to open, reduced depolarisation, disruption of action potential generation, damage to the myelin sheath reducing saltatory conduction or impaired transmission across synapses.
- Strong responses linked these changes directly to hearing loss.

Limited responses

- Others referred generally to damage to nerves without identifying the roles of ion channels, membranes, myelin or synapses.

Question 8

(a) Comprehensive responses

- Most candidates correctly identified the DNA sample, primers, free DNA nucleotides and Taq polymerase as the materials required for PCR.
- Better responses recognised that Taq polymerase must be heat stable.

Limited responses

- Some candidates referred only to DNA polymerase without recognising the importance of heat stability.
- Some responses referred only to nucleotides rather than free DNA nucleotides.

(b) Comprehensive responses

- Many candidates gave a logical account of the PCR cycle.
- Better responses correctly described denaturation, primer annealing and strand extension in sequence and included appropriate temperatures.
- Many candidates correctly explained that hydrogen bonds are broken during denaturation, primers bind by complementary base pairing, and Taq polymerase joins DNA nucleotides together to synthesise complementary strands.

Limited responses

- Many candidates described denaturation accurately but gave less complete accounts of annealing and extension.
- Some responses omitted the role of primers.
- Some candidates were uncertain of the function of Taq polymerase.
- A few responses described the stages out of sequence or omitted key details, limiting access to full marks.

Question 9

(a) (i) Comprehensive responses

- Many candidates described the sequence of events leading to trap closure in the Venus fly trap.
- Better responses linked stimulation of trigger hairs to electrical signalling, ion movement, water movement and changes in the turgor of specific hinge cells.
- Strong responses clearly identified the locations at which each stage occurred.

Limited responses

- Some candidates identified incorrect ions.
- Some responses described the whole leaf becoming turgid rather than changes in the turgor of specific cells.
- A number of responses lacked sufficient detail or confused the sequence of events.

(ii) Comprehensive responses

- Some candidates recognised that Venus fly traps typically grow in soils deficient in mineral ions, particularly nitrate ions.

Limited responses

- Many candidates focused on nutrients obtained from insects rather than deficiencies in the soil.
- A common error was to refer to nitrogen rather than nitrate ions.

(b) Comprehensive responses

- Many candidates compared the two biological responses using appropriate biological terminology.
- Better responses made clear comparisons between the mechanisms and correctly referred to neurones, action potentials and the duration of responses.

Limited responses

- Some candidates used the term *nerve cell* rather than *neurone*.
- Some responses confused speed with duration, referring to fast and slow responses rather than responses of short or long duration.
- Several responses lacked direct comparisons between the two mechanisms.

Question 10

(a) Comprehensive responses

- Many candidates gave a detailed and logically sequenced account of glycolysis.
- Better responses included phosphorylation of glucose, formation and splitting of hexose biphosphate, oxidation of triose phosphate, reduction of NAD and substrate-level phosphorylation.
- Many candidates correctly identified pyruvate, ATP and reduced NAD as the products of glycolysis.

Limited responses

- Some candidates identified the products of glycolysis but did not explain the reactions leading to their formation.
- Some responses confused the early stages of glycolysis, particularly the phosphorylation of glucose and oxidation of triose phosphate.
- A few candidates omitted key stages, limiting access to the higher marks.

(b) Comprehensive responses

- Many candidates correctly explained how a reduced concentration of coenzyme A affected the subsequent stages of aerobic respiration.
- Better responses recognised that less acetyl coenzyme A would be formed, reducing the rate of the Krebs cycle and the production of reduced NAD and reduced FAD.
- Strong responses linked this to fewer electrons entering the electron transport chain, reduced proton pumping, a smaller proton gradient and reduced ATP synthesis by oxidative phosphorylation.

Limited responses

- Some candidates simply described the Krebs cycle without explaining the consequences of reduced coenzyme A.
- Some responses stated only that less ATP would be produced without developing the biological explanation.
- A few candidates incorrectly described anaerobic respiration or lactic acid fermentation.

(c)

Comprehensive responses

- Most candidates correctly identified the structures within the mitochondrion.
- Better responses recognised that ATP synthase is located in the inner mitochondrial membrane and that the highest proton concentration occurs within the intermembrane space.

Limited responses

- The most common error was confusion between the outer and inner mitochondrial membranes and labelling D.

BIOLOGY

Paper 9700/51 Planning, Analysis and Evaluation
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Key messages

What candidates did well

- Most candidates demonstrated effective investigation planning skills, taking account of the independent, dependent and standardised variables.
- Many candidates demonstrated competent statistical skills, including the use of a *t*-test to analyse unfamiliar data.
- Some candidates applied their knowledge and understanding of biological processes to the investigations in the question paper.
- Some candidates gave a variety of different points when writing conclusions and evaluations. Elaborating on the same point many times is a less successful strategy.

What candidates needed to improve

- When writing a plan for an investigation, it is important to set out the work in a logical way and for it to be detailed enough for another person to follow.
- Careful reading of each question before starting to write is important. The command word and the number of allocated marks should be used to understand how to answer each question.
- Many candidates repeated information from the question stem. Candidates should be reminded to provide more information in their answers.
- Candidates should take care to use the correct terminology when completing statistical analysis.

Comments on specific questions

Question 1

(a) (i) Comprehensive responses

- Some candidates appreciated that the oxygen used in respiration and carbon dioxide absorbed by sodium hydroxide would lead to a decrease in volume or pressure.

Limited responses

- Most candidates stated that the drop of coloured liquid would move to the left. Some candidates did not link this movement to the decrease in volume or pressure.
- A few candidates stated that the drop of coloured liquid would move to the right.

(ii) Comprehensive responses

- Some candidates described a suitable control for this investigation.

Limited responses

- A few candidates used no *O. asellus* in the respirometer and did not suggest a suitable replacement for the living organism.
- A few candidates suggested a variety of standardised variables.

(iii) Comprehensive responses

- Most candidates were able to describe a suitable method, giving enough detail for another person to be able to follow their method.
- Most candidates stated an appropriate range of five temperatures for the independent variable.
- Most candidates explained how several variables should be standardised.

- A few candidates gave a clear method that would allow for the equilibration of *O. asellus* at each temperature.
- Some candidates described how the dependent variable should be measured using the respirometer and included the need for replicates to be taken. These candidates stated clearly that measurements should be taken 'at each temperature'.
- Most candidates included a risk assessment.

Limited responses

- A few candidates gave an incomplete range of temperatures that did not include 5 °C and 35 °C.
- A few candidates standardised the temperature using a temperature-controlled room. A water bath would be more appropriate for this investigation.
- Some candidates attempted to standardise the concentration or number of sodium hydroxide pellets.
- Some candidates measured the distance moved by the drop of coloured liquid and did not also measure the time. Both distance and time measurements are required to calculate the rate of respiration.
- Most candidates suggested the use of replicates. At least three replicates should be carried out for 'each temperature'.
- In their risk assessment, some candidates suggested that sodium hydroxide would be an irritant. Solid sodium hydroxide is corrosive.

(iv) Comprehensive responses

- Some candidates described a correct method to calculate the rate of respiration, often using πr^2 to calculate the cross-sectional area of the glass tube.

Limited responses

- Some candidates divided volume by time or divided distance by time with no reference to the cross-sectional area of the glass tube.

(b)(i) Comprehensive responses

- Most candidates used information from the question to correctly identify the independent variable.

Limited responses

- A few candidates incorrectly suggested the concentration of the respiratory substrate. This is a standardised variable and is not the independent variable.

(ii) Comprehensive responses

- Most candidates described a correct method to obtain a 20% solution of glucose.

Limited responses

- Some candidates did not specify that distilled water should be used as the diluent.
- A few candidates attempted to use a 20% stock solution of glucose instead of the 50% stock solution.

(iii) Comprehensive responses

- Most candidates standardised aspects of the investigation such as the temperature or the species of yeast. These variables had not been standardised by the student.

Limited responses

- Some candidates incorrectly suggested variables that the student had already standardised in the investigation.

(c)(i) Comprehensive responses

- Some candidates correctly identified the type of data shown by the respiratory substrate.

Limited responses

- Some candidates suggested that the type of data was discrete or continuous. These types of data are quantitative and incorrect for the respiratory substrate.

(ii) Comprehensive responses

- Most candidates used Figure 1.5 to state a conclusion for the investigation, supporting this with correct data quotes.

Limited responses

- A few candidates did not give data quotes from Figure 1.5 to support their conclusion.
- A few candidates gave incorrect data quotes from Figure 1.5 or did not include units with their data quotes.

(iii) Comprehensive responses

- Some candidates used their knowledge of monosaccharides and disaccharides to explain why the rate of fermentation with maltose is slower than the rate of fermentation with glucose.
- A few candidates understood that maltose would only enter glycolysis after hydrolysis.

Limited responses

- Some candidates mentioned maltose and hydrolysis without explaining that maltose needs to be hydrolysed because it is a disaccharide.
- Some candidates stated that glucose is easier to use for respiration. Glycolysis was rarely mentioned.

Question 2

(a) (i) Comprehensive responses

- Most candidates correctly explained why a *t*-test should be chosen.

Limited responses

- Some candidates stated that a *t*-test is used to compare two means. This information was given in the question stem and was therefore not required.

(ii) Comprehensive responses

- Most candidates stated the null hypothesis, giving well-written answers that included no difference, bill length, the birds and the song types.

Limited responses

- A few candidates stated that there was no difference between the mass, bill width and bill depth (perhaps copying this from the question stem).
- Only a few candidates gave the alternative hypothesis.

(iii) Comprehensive responses

- Most candidates correctly calculated the number of degrees of freedom.

Limited responses

- A few candidates gave the total number of *G. conirostris* or only subtracted 1 from the total number, therefore stating an incorrect number of degrees of freedom.

(iv) Comprehensive responses

- Most candidates identified the correct critical value, stating that this critical value was less than the calculated *t*-value.
- Most candidates then stated a correct conclusion for the *t*-test.

Limited responses

- A few candidates did not use Table 2.2 to identify the correct critical value for the investigation.
- A few candidates did not use the correct terminology. The '*t*-value' could refer to either the calculated or the critical value of *t*.

(b) Comprehensive responses

- Some candidates measured the time spent feeding on each food source. To collect valid data, *G. conirostris* should be given a choice of food sources.
- A few candidates suggested a method to observe *G. conirostris* feeding, such as using a camera.
- A few candidates used different coloured rings or marks to identify *G. conirostris* from each song type.

Limited responses

- Some candidates gave a brief method that did not include observation of *G. conirostris* or did not mention feeding.
- Some candidates did not measure the time spent feeding. Instead, another variable was measured, such as the change in mass of the food or the number of *G. conirostris* present on each food source.
- A few candidates suggested the use of trackers. A tracker would identify the location of each *G. conirostris* but would be less helpful as a method to observe feeding.
- A few candidates described mark-release-recapture.

(c) Comprehensive responses

- Some candidates answered the question in two parts, firstly, the support for the conclusion and then how to extend the investigation.
- Some candidates noted the lack of geographical separation between the two groups of *G. conirostris*.
- A few candidates stated specific improvements that were relevant to this investigation, such as studying the female birds or DNA analysis.

Limited responses

- Some candidates only outlined how the conclusion could be supported. These candidates did not consider how to extend the investigation.
- Some candidates gave factual statements about sympatric speciation that were not applied to this investigation.
- Most candidates identified the differences between the two groups of *G. conirostris*. These phenotypic differences should then be linked to differences in selection pressures or to reproductive isolation.
- Some candidates gave generic improvements such as repeating the investigation or increasing the sample size.

BIOLOGY

Paper 9700/52 Planning, Analysis and Evaluation
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Key messages

What candidates did well

- Most candidates demonstrated knowledge and experience of practical procedures.
- Most candidates demonstrated competent mathematical skills.
- Many named and described the use of scientific apparatus throughout.
- Some responses showed evidence of planning, by highlighting sections of the information provided and listing the requirements for producing a method for an investigation.

What candidates needed to improve

- Candidates needed to improve their understanding of command terms.
- Candidates should use correct scientific terminology in all responses.
- Candidates should use the mark allocation to determine the level of detail required in their answers.
- Candidates should pay attention to the information provided and carefully consider the question to identify what is being asked.

Comments on specific questions

Question 1

(a) Comprehensive responses

- Many demonstrated an understanding of safety procedures during practical work.
- Many candidates gave clear responses, stating one hazard with an appropriate risk and precaution.

Limited responses

- Many candidates stated more than one hazard. In these responses, understanding of which hazard matched which risk or precaution was not clear.
- Some candidates:
 - confused irritant with allergy
 - did not include the risk in their responses
 - stated 'burns' as an alternative to the corrosive/irritant aspect of hydrogen peroxide
 - suggested gloves as a suitable precaution when using knives or scalpels; gloves are not suitable and could reduce the careful use of knives or scalpels.

(b)(i) Comprehensive responses

- Many recognised that the independent variable should be categorised.
- Many recognised that a range of different levels of ripening was required.

Limited responses

- Some confused maturity of avocados with the ripeness of avocados.
- Few candidates recognised that the ripeness of the avocado needed to be stated or described.
- A few candidates stated the dependent variable.
- Candidates needed to make use of the information provided.
- Some candidates referred to the levels of catalase activity.

(ii) Comprehensive responses

- Many candidates used the information provided to describe how different levels of ripeness could be achieved.
- Many candidates demonstrated knowledge of practical procedures and the use of appropriate laboratory equipment, such as gas syringes.
- Many candidates provided methods that were clear, concise and detailed enough to be followed.
- Candidates identified the controlled variables and how these variables were controlled.

Limited responses

- Many candidates suggested counting bubbles which is impractical.
- Some candidates gave lengths of time for ripening that were either too long, such as weeks, or too short, such as minutes.
- Some candidates named suitable apparatus without describing how the apparatus was used, such as the use of a water-bath.
- Some candidates selected hydrogen peroxide concentration as the independent variable.
- Some candidates suggested using a slow-motion camera or video to enable bubbles to be counted.
- A few candidates stated the need to replace hydrogen peroxide when repeating the experiment.
- A few candidates provided information about data processing which was not required.

(c) (i) Comprehensive responses

- Many candidates recognised that a random number generator should be used.
- Some candidates recognised that the trees should be numbered.

Limited responses

- Many responses only referred to the use of a random number generator.
- Many referred to using the co-ordinates of each tree with a random number generator, which was not appropriate with so many trees in a small area.

(ii) Comprehensive responses

- Some candidates were able to apply their knowledge to link high external humidity with a reduction in water loss from the avocados.

Limited responses

- Many candidates needed to understand the impact of high external humidity on water loss.
- Many responses were vague, simply referring to preventing the avocados from drying out.
- Some candidates suggested that the high humidity would reduce the rate of ripening.

(iii) Comprehensive responses

- Most candidates were able to calculate the 95 per cent confidence levels.

(iv) Comprehensive responses

- Many error bars were drawn using a fine pencil and a ruler to create a clear line.
- Many candidates read the scale on the y-axis with precision.

Limited responses

- Some candidates needed to read the scale on the y-axis with greater care.
- Some horizontal bars were sloping, so plotting was inaccurate.

(v) Comprehensive responses

- Few candidates:
 - provided clear overall conclusions for the two sets of data.
 - used data to support the conclusions.
 - used appropriate language to describe the impact of overlapping error bars on the significance of the differences seen.

Limited responses

- Many responses listed data quotes; these needed to be linked to conclusions.
- Many focused on the lowest and highest means.
- Many only referred to d data or the dR data.
- Some compared the means of the d and dR groups with those of the freshly harvested avocados.
- Some lacked detail; error bars should have been mentioned, including which error bars overlapped.
- Some compared just one data point from each group.
- Responses needed to provide an overview of the impact of the two treatments.

(vi) Comprehensive responses

- Few candidates used their knowledge of the t-test to describe why it was not suitable.

Limited responses

- Many candidates listed the requirements for a t-test; this was not what the question asked for.
- Many confused data or values with means.
- Many described the data as 'not continuous'.

Question 2

(a) (i) Comprehensive responses

- Some candidates demonstrated an understanding of the use of dichotomous keys for species identification.

Limited responses

- Many candidates only referred to the information provided in the question regarding the features of butterflies. Candidates needed to understand how these features are used for identification.

(ii) Comprehensive responses

- Many candidates demonstrated an understanding of controlled variables.
- Many stated that the length and the time of year were key variables.

Limited responses

- Candidates should be aware that a simple reference to time was too vague. Time needed to be qualified with reference to the day, year or season.

(iii) Comprehensive

- Many responses included the features of butterflies that would have an impact on the data.
- Some candidates understood the need to discuss the features of butterflies and how these would affect the quality and reliability of the data.
- Many responses focused on the numbers of butterflies counted.
- Few responses discussed the identification of species.

Limited responses

- Many candidates needed to understand the command word 'discuss' so that their responses would contain all the required aspects.
- References to miscounting or misidentification were often not seen.
- A misunderstanding of the question resulted in responses that included reference to techniques such as capture, mark-release and the use of nets to catch the butterflies.

(b) Comprehensive responses

- Many candidates understood that rural areas would provide more habitats and food.

Limited responses

- Some responses needed to make a clear comparison between the urban and rural areas.

(c) Comprehensive responses

- Many responses clearly set out correct working, with the answer rounded to three significant figures.

Limited responses

- Candidates had answers with four significant figures.
- Some candidates used the incorrect figure as the denominator.
- Some candidates took incorrect readings from the graph.
- Few candidates provided two different sets of calculations with different answers; this is not accepted.

BIOLOGY

Paper 9700/53 Planning, Analysis and Evaluation
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Key messages

What candidates did well

- Some candidates demonstrated effective investigation planning skills, taking account of the independent, dependent and standardised variables.
- Most candidates demonstrated competent mathematical skills. Candidates were able to outline the steps to determine the rate of respiration from a respirometer and to calculate respiratory quotient, giving their answer to an appropriate number of significant figures.
- Statistical analysis of unfamiliar data was completed competently by some candidates.

What candidates needed to improve

- When planning an investigation, it is important to set out the work in a logical way and for it to be detailed enough for another person to follow. Candidates should practise planning a range of different investigations, using a numbered list to express their ideas in a coherent and concise manner.
- Careful reading of each question before starting to write is important. Candidates should use the command word and the number of allocated marks to understand how to answer each question.
- Candidates should take care to use the correct terminology when completing statistical analysis.

Comments on specific questions

Question 1

(a) (i) Comprehensive responses

- Many candidates correctly sketched the curve predicting the results, with appropriately labelled axes.

Limited responses

- Some candidates' curves did not include the doubling rate at the beginning or the effect of high temperature at the end.

(ii) Comprehensive responses

- Some candidates were able to describe a suitable method, giving enough detail for another person to be able to follow their method.
- Many candidates stated an appropriate range of five temperatures for the independent variable.
- Some candidates considered the investigation carefully and explained how several variables should be standardised.
- Many candidates described how the dependent variable should be measured and included the need for replicates to be taken. These candidates stated clearly that measurements should be taken 'at each temperature'.
- Some candidates included a risk assessment with appropriate details of the hazard, risk and precaution.
- A few candidates suggested the need to acclimatise the seeds to each new temperature.

Limited responses

- A few candidates did not state the temperatures to be used or gave temperatures that were outside the temperature range being used by the student.
- Some candidates suggested methods to vary the temperature that were not appropriate to this investigation. To vary the temperature, a water bath is appropriate. A temperature-controlled room would not be suitable.
- A few candidates were not clear about how the dependent variable should be measured 'at each temperature'.
- Some candidates mistakenly thought the syringe in the respirometer was a gas syringe used to measure the volume of gas evolved.
- Most candidates suggested the use of replicates. At least three replicates should be carried out for 'each temperature'.

(iii) Comprehensive responses

- Many candidates described some of the mathematical steps needed to calculate the rate of respiration. Some candidates used formulae to make their answers more concise.

Limited responses

- Some candidates did not see the capillary tube as a cylinder when making their calculations.
- Many candidates noted that their calculated value should be divided by time to determine the rate.

(b)(i) Comprehensive responses

- Most candidates correctly calculated the respiratory quotient (RQ).

Limited responses

- Some candidates divided the volume of oxygen by the volume of carbon dioxide.

(ii) Comprehensive responses

- Most candidates correctly identified the species with the unexpected results and supported their answer with an appropriate reason.

Limited responses

- Some candidates chose species C as it had lower values than the other species.

(iii) Comprehensive responses

- A few candidates suggested an appropriate error in the method to account for the unexpected result in **1(b)(ii)**. Most responses focussed on the loss of gas.

Limited responses

- Many candidates did not describe how a change in temperature or time during the investigation would lead to the unexpected result.
- Some candidates referred to gas entering the reaction vessel causing the unexpected result.

Question 2

(a) Comprehensive responses

- Most candidates extracted information from the question to correctly identify the independent and dependent variables.

Limited responses

- A few candidates referred to garlic without stating garlic capsules.
- A few candidates swapped the independent and dependent variables.

(b) Comprehensive responses

- A few candidates suggested a suitable method for the control group, with many referring to placebo capsules or pills.

Limited responses

- Most candidates removed garlic from the patients' diets without the inclusion of a capsule.

(c) (i) Comprehensive responses

- Some candidates correctly identified the type of data represented.

Limited responses

- Some candidates misidentified the type of data represented.

(ii) Comprehensive responses

- Many candidates identified the treatment which resulted in the greatest decrease in pressure.
- A few candidates compared the difference in pressure between the start and the end of the investigation and the difference between groups.
- Some candidates compared each group with the control group.
- A few candidates used standard error (SE) to support their statements.

Limited responses

- Many candidates compared the results between different treatments without comparing them to the control.
- Many candidates compared intermediate values without focussing on the start and the end of the investigation.
- Most candidates did not use SE to support their statements.

(iii) Comprehensive responses

- A few candidates correctly explained why a *t*-test is not the appropriate statistical test by referring to the distribution of the data.

Limited responses

- Some candidates did not recognise the means for the different treatments as being different means.

(d) Comprehensive responses

- Many candidates stated valid changes to the procedure to increase confidence in the conclusions.
- Some candidates focussed on the test subjects and wider investigation.

Limited responses

- Some candidates stated two changes that should be applied to the test subjects only.

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Key messages

What candidates did well

- Some candidates demonstrated their knowledge and experience of practical biology by writing methods that were detailed enough to be followed by another person.
- Most candidates demonstrated competent mathematical skills. Candidates were able to calculate R_f values, complete a chi-squared statistical test and interpret error bars showing 95 per cent confidence intervals.
- Some candidates were able to effectively use information from the question stem to evaluate unfamiliar data.

What candidates needed to improve

- When planning an investigation, the method should be set out in a logical way and be detailed enough for another person to follow it. A list of the independent, dependent and standardised variables is not the same as a detailed step-by-step method.
- Careful reading of each question before starting to write is important. Candidates should use the command word and the number of allocated marks to understand how to answer each question.
- A few candidates did not use the correct terminology when completing statistical analysis.

Comments on specific questions

Question 1

(a) Comprehensive responses

- Most candidates used Figure 1.2 and Table 1.1 to correctly identify pigment 1 and pigment 2.

Limited responses

- A few candidates measured to the top of pigment 2 and incorrectly identified it as xanthophyll. The distance to the centre of the pigment should be used to calculate the R_f value.

(b)(i) Comprehensive responses

- Some candidates were able to describe a suitable method for the investigation, giving enough detail for another person to be able to follow their method.
- A few candidates described a method to select or grow plants in direct sunlight and in shade. Plants should be grown in different light intensities for a long enough time to allow the production of specific chloroplast pigments.
- Some candidates used their practical experience of chromatography to identify the correct apparatus and describe how to prepare separate leaf extracts and chromatograms.
- A few candidates standardised the chromatography procedure by using a named solvent.
- Some candidates described how to measure the distances on the chromatogram so that R_f values could be calculated.

Limited responses

- Most candidates collected leaves from plants growing in direct sunlight and in shade. For the shade condition (low light intensity), the plant should not be kept in the dark.
- Some candidates did not include details of how to prepare leaf extracts and set up the chromatograms.

- Some candidates standardised various aspects of the laboratory environment, such as the temperature. For this investigation, it is more important to standardise the solvent and paper used for chromatography.
- Most candidates stated the formula used to calculate R_f values. For the dependent variable, candidates should describe the exact measurements that need to be taken.

(ii) Comprehensive responses

- Some candidates suggested a risk, the hazard associated with that risk and a relevant precaution. For example, the solvent is toxic and a fume cupboard should be used.

Limited responses

- Some candidates focused on the stinging nettles and did not suggest a different hazard.
- A few candidates suggested gloves as a precaution when this was already stated in the risk assessment.

Question 2

(a) Comprehensive responses

- Most candidates used the information provided to correctly identify the two dependent variables.

Limited responses

- A few candidates incorrectly identified the dependent variables as the rate of photosynthesis. Although this was the broader biological process being investigated, this answer lacks the specificity required by the question.
- A few candidates referred to DCPIP production rather than to DCPIP reduction.

(b) Comprehensive responses

- Most candidates correctly identified a variable that should be standardised in the second experiment.

Limited responses

- Some candidates suggested variables that had already been standardised in the question, such as the volumes of solutions.
- A few candidates incorrectly suggested standardising the concentration of sodium chloride; this is the independent variable.

(c) Comprehensive responses

- A few candidates explained that the outcome of the second experiment depended on DCPIP entering the cells.
- A few candidates linked partial hydrolysis of the bacterial cell walls to increased permeability of the cell wall.

Limited responses

- Some candidates could not suggest a reason for the use of the enzyme in the second experiment. Limited responses sometimes suggested that the enzyme would make the experiment 'easier' or 'more efficient'.
- Some candidates referred to substances such as sodium chloride, NADP or H^+ ions but did not mention DCPIP in their answers.

(d) Comprehensive responses

- Most candidates correctly completed Table 2.1 to show how the solutions could be made by proportional dilution.

Limited responses

- A few candidates recognised the expected pattern of stock solution volumes and water volumes, then made arithmetic errors in individual rows.

(e) Comprehensive responses

- Some candidates used Figure 2.2 to describe the pattern and state the sodium chloride concentrations that gave the highest rates.

Limited responses

- Some candidates gave values from the y-axis, but the different scales and units did not lead to a valid comparison.
- A few candidates did not include units with their data quotes from Figure 2.2.

Question 3

(a) Comprehensive responses

- Most candidates used Figure 3.1 to give an overall conclusion for the investigation.
- Some candidates used the correct terminology to describe the significant difference indicated by error bars that do not overlap (and vice versa).

Limited responses

- Some candidates stated that error bars overlapped and then did not include sufficient detail in their answer. For example, stating 'significant effect' instead of 'significant difference'.
- A few candidates incorrectly stated that all the error bars in Figure 3.1 overlapped. Error bars should be compared two at a time.
- A few candidates noted the large error bar shown by non-GM *M. pingshaense* and linked this to less reliable data. The large error bar indicates that the mean is less reliable.

(b)(i) Comprehensive responses

- Most candidates described the use of a net to cover the entire experimental area.

Limited responses

- A few candidates used a net on only the windows and doors of the hut.
- A few candidates suggested the use of insecticide. This would kill the mosquitoes and therefore affect the results of the investigation.

(ii) Comprehensive responses

- Most candidates completed Table 3.2 to correctly calculate the value of χ^2 .

Limited responses

- A few candidates did not give the value of χ^2 to three significant figures.
- A few candidates correctly calculated the values for the final column of Table 3.2 and then entered these values into a calculator incorrectly. Candidates should be encouraged to sense-check their final value with a simple addition task.

(iii) Comprehensive responses

- Some candidates identified the correct critical value from Table 3.3 and then gave a full and complete answer.

Limited responses

- Some candidates identified the correct critical value and stated that the calculated value is greater than the critical value. These candidates did not complete their answer by stating that the candidate was correct.
- Some candidates did not identify the correct degrees of freedom or the correct critical value.

(c) Comprehensive responses

- Most candidates described how the data in Table 3.1 and the calculated value of χ^2 support the conclusion, with good use of terminology.
- Some candidates gave detailed suggestions for further information that would be needed, such as the potential for harm to humans or ecosystems, or whether mosquitoes might become resistant to GM *M. pingshaense*.

Limited responses

- Some candidates focused on how the data support the conclusion or on what further information would be needed. Both aspects are required to give a full response.
- A few candidates referred to the reproduction of the mosquitoes and did not refer to the number of mosquitoes. The terminology from Table 3.1, 'number of mosquitoes', should be used.

- Some candidates only suggested one piece of further information that would be needed or stated that more repeats should be carried out. Mosquitoes only reproduce during the rainy season, so repeats in other seasons would not give valid results.