BIOLOGY

Paper 9700/11
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Question 1

The majority of candidates answered correctly, with only the weakest candidates finding it difficult.

Questions 2, 4, 6, 16, 19, 23, 30, 34, 37 and 38

Almost all candidates found these questions straightforward and answered correctly.

Question 3

Some candidates found this question difficult. Only the stronger candidates were aware that microtubules carried out all three of the listed functions.

Question 5

Many candidates answered correctly. The majority of stronger candidates and some of the weaker candidates knew that all four cell structures have ribosomal RNA.

Question 7

Some candidates found this question difficult, with many incorrectly selected options **B** or **D**. Since amylase is an enzyme, the test with biuret reagent should give a purple result.

Questions 8, 27 and 28

The majority of stronger candidates answered correctly, whilst weaker performing candidates selected each option almost equally.

Question 13

Some candidates found this question difficult, although most of the stronger candidates performed well. The most common incorrect answer was to select option **A**. Whilst this statement is true, it does not explain the trend in the results. It is option **C** that explains the trend.

Question 15

The majority of the stronger candidates correctly interpreted the graph to select option **A**. The most common incorrect answer was to select option **D**. However, if the *y*-axis was rate of entry of glucose into the cell, then option **D** was not possible.

Question 17

Most candidates answered correctly. Some incorrectly selected option **C** and a few selected option **A**.

Question 18

This was answered correctly by many candidates, although a number found it more difficult. During telophase, each newly formed nucleus will contain the diploid number (38) of chromosomes. Therefore, since each chromosome has one telomere at each end, there will be 38 · 2 telomeres in one nucleus.

Question 24

Whilst the majority of stronger candidates answered correctly, most of the weaker candidates chose option **C** or option **D**. Many candidates did not take into account that the DNA was double-stranded.

Question 31

Many candidates found this question difficult. The most common incorrect answer was to select option **B**.

Question 32

The vast majority of the stronger candidates answered correctly. Most of the candidates who answered incorrectly had selected options containing statement 2.

Questions 33, 35 and 39

Most candidates, particular the stronger candidates, answered correctly.

Question 40

Most candidates, particular the stronger candidates, answered correctly. However, some candidates thought that all three cell types could divide continuously and so incorrectly selected option **A**.

BIOLOGY

Paper 9700/12
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Questions 1, 5, 7, 10, 13, 15, 18, 20, 21, 23, 25, 31, 34, 36, 37 and 38

The vast majority of candidates found these questions straightforward and answered them correctly.

Question 3

Many candidates found this question difficult. Most of the stronger performing candidates answered correctly, realising that both mitochondria and chloroplasts have circular DNA. The most common incorrect answer was option **B**, even though mature red blood cells contain no organelles and no DNA.

Question 4

Whilst the majority of stronger performing candidates answered correctly, some candidates incorrectly chose option **D**.

Question 8

Most candidates answered correctly and realised that the primary, secondary and tertiary levels of protein must be involved in forming the active site. Not all enzymes will have a quaternary structure.

Question 11

Many candidates found this difficult and incorrectly chose either option **B** or option **D**. Using the information provided in the question and noting that the *y*-axis is labelled as the rate of reaction, candidates should have realised that the rate must start high, and therefore option **C** must be correct.

Question 16

The majority of candidates found this question difficult. From the information supplied, candidates were required to identify that all three cell types would undergo many mitotic cell cycles.

Question 19

Whilst almost all candidates knew that statements 1 and 4 were correct, only the strongest candidates realised that statement 3 was also correct.

Question 27

Most candidates answered correctly. The most common incorrect answer was to select option **C**. Only a longitudinal section of a heart could contain both the right atrium and right ventricle.

Question 30

The majority of all candidates knew that all three tissues were present and so answered correctly. The most common incorrect answer was to select option **C**.

Question 32

A majority of candidates answered correctly. The weaker candidates mostly chose options where alveoli contain smooth muscle tissue.

Question 33

Whilst the vast majority of all candidates selected options that included statement 3 (the only correct statement), many also thought that statement 1 or statement 2 was also correct.

Questions 39 and 40

The vast majority of stronger candidates had little difficulty with these questions and most candidates overall answered correctly. Only a minority of the lower performing candidates answered correctly.

BIOLOGY

Paper 9700/13
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Questions 1, 6, 8, 23, 12, 18, 20, 31, 37, 38, 39 and 40

The vast majority of candidates found these questions straightforward and answered correctly.

Question 3

The majority of candidates found this question difficult. In order for proteins to be secreted they need to be packaged in the Golgi body and then leave the cell via exocytosis.

Question 4

Most candidates answered correctly. Some incorrectly suggested that lysosomes have a double membrane.

Questions 5, 15, 29 and 33

The majority of stronger performing candidates answered correctly, whilst the weaker candidates selected each option almost equally.

Question 7

Many candidates found this question difficult and incorrectly selected option **A** or option **C**. Since amylase is an enzyme, the test with biuret reagent should give a purple result.

Question 11

The majority of all candidates could identify the correct description for a triglyceride.

Question 13

Most candidates found this question difficult, with only a minority answering correctly. The most common incorrect answer was to select option **C**.

Question 14

The vast majority of the stronger candidates and some of the weaker candidates answered correctly.

Question 19

Most candidates were able to process the information in order to obtain the correct answer.

Question 21

Many candidates answered correctly. Most of the weaker candidates incorrectly selected option **C**.

Question 22

Most of the stronger candidates answered correctly but, overall, many found this question very difficult. From the information supplied, candidates needed to identify which of the three cell types would undergo many mitotic cell cycles, namely stem cells and activated memory B-lymphocytes.

Question 25

Whilst the majority of stronger candidates answered correctly, the weaker candidates selected the range of options.

Question 27

Whilst the majority of candidates were able to process this information and had no difficulty in answering correctly, a minority incorrectly chose either option **C** or option **D**.

Question 32

Many candidates found this difficult, with option **B** as the most common incorrect answer. As a capillary wall is only formed by a layer of endothelial cells, neither option **B** nor option **C** can be correct.

Question 34

Whilst the majority of the stronger candidates answered correctly, others found this question difficult. The most common incorrect answer was to select option **A**.

Question 35

Candidates found it difficult to work out the number of layers of membrane and all options were selected across the range of abilities. However, the majority of stronger candidates reasoned correctly that a total of 5 cell surface membranes separate the oxygen molecule and the haemoglobin molecule.

Question 36

The vast majority of the stronger candidates answered correctly, although across the ability range, all options were chosen. Most of the weaker performing candidates thought that carboxyhaemoglobin is formed when carbon dioxide combines with haemoglobin and incorrectly selected option **C** or option **D**.

BIOLOGY

Paper 9700/21
AS Level Structured Questions

Key messages

Candidates should use biological terms accurately. For example, in **Question 1(a)**, the secondary structure of antibodies can be described as having beta or β-pleated sheets, not B-pleated sheets and, in **Question 1(b)(ii)**, B-lymphocytes or B cells should be stated, rather than β cells.

When quoting extracted data from graphs, candidates are reminded to refer to both axes in their answers. In **Question 3(a)(ii)**, many often omitted the time. In addition, it was better to refer to a specific time from the *x*-axis rather than to state 'at the end'.

The preliminary information in the form of text, graphs and tables should be read carefully before attempting the questions that follow. For example, in **Question 3**, many candidates did not understand that Neutrase® was an enzyme that catalysed the hydrolysis of protein to amino acids.

Candidates should be able to link structural and functional features of cells and tissues named in the syllabus. This was the main focus of **Question 4**. Candidates often answered **Question 4(c)** by describing the function of phloem sieve tubes without explaining how the structure of sieve tube elements was related to the transport of sucrose and other assimilates.

General comments

In **Question 3(a)(ii)**, errors in reading data from the graph could have been reduced by the use of a ruler to follow gridlines to their intersections on **Fig. 3.1**. In **Question 4(b)**, many candidates did not make effective use of the information in **Fig. 4.1** about the differentiation of phloem sieve tube elements in order to complete the table.

In **Question 1(b)(iii)**, **Question 2(a)(ii)** and **(c)**, and **Question 6(b)(ii)** and **(iii)**, there were opportunities for candidates to discuss molecules binding to each other. Often, candidates did not use the word bind or binding or an equivalent word such as attach or combine, so did not gain credit. For example, the function of cell surface receptors for thromboxane was often described as to 'detect the presence' of the cell signalling molecule.

Answers often included vague language, such as 'copper sulfate affects enzymes' in **Question 3(a)(ii)** rather than 'copper sulfate decreases enzyme activity'. This question specifically asked the effects on the *activity* of an enzyme, but many did not plan their answers accordingly. The term phloem was often used instead of sieve tube element in **Question 4(d)**.

The questions on sieve tube elements and companion cells in **Question 4** required candidates to adapt their knowledge to the requirements of the questions, which many found challenging.

When comparing triglyceride and phospholipid structure in **Question 2(b)(ii)**, many candidates mentioned that triglycerides have three fatty acid tails, but did not mention the number in phospholipids.

There were many candidates who did not attempt questions or wrote no more than a repeat of the information given in the question. Many good answers to some of the questions often gave far more information than was required and so used up time but gained no further credit. For example, candidates often wrote about all of the stages of hybridoma formation in **Question 1(b)(iii)**.

Comments on specific questions

Question 1

(a) Almost all candidates identified the presence of β-pleated sheets as secondary structures in the diagram of the antibody molecule. Many also stated that α-helices were present as well, although there was very little evidence for this in **Fig. 1.1**. Very few described the irregular or random arrangement of the secondary structure. Candidates found it more difficult to describe the tertiary structure. Many stated that the diagram showed the 3D structure or 3D shape, but fewer explained this in terms of further folding of a polypeptide. Some candidates gave descriptions of quaternary structure, which was not required.

(b) (i) Many knew that structure **X** was involved in some aspect of polypeptide or protein synthesis, but not all used the term polypeptide or protein. Some stated that **X** produces antibodies, which gained no credit as this was given in the question. A number of candidates identified the structures labelled **X** and **Y** in **Fig. 1.2** as rough endoplasmic reticulum and mitochondrion respectively. Naming the structures was not required, but if the structure was incorrectly named, then credit could not be given for the role. A common error was to state that **X** makes ribosomes. Candidates were less successful at identifying the role of **Y** as producing ATP for protein synthesis. **Y** was also often misidentified as a Golgi body, vesicle, lysosome or nucleus. Many responses stated that **Y** produces energy which was not credited. A considerable number of candidates got the answers to **X** and **Y** the wrong way around.

(ii) There were some excellent answers seen for this question. However, many spent time outlining all of the stages, starting with the injection of an antigen into a suitable animal. The most common error was to state that hybridomas were formed by fusion of antibodies with myeloma cells rather than the fusion of plasma cells with myeloma cells. Many candidates referred to the use of a fusogen. A few good candidates gave examples of fusogens, such as polyethylene glycol or an electric current. Weaker responses did not gain credit as they referred to lymphocytes without qualification or suggested that T-lymphocytes were involved in hybridoma production as well. Some gave descriptions of mitosis instead of cell fusion.

(iii) Some candidates knew that diseases such as Ebola have been treated using monoclonal antibodies and many described their role in the treatment of cancers and autoimmune diseases. A much smaller number of candidates stated that drugs, radioactive isotopes and enzymes can be attached to monoclonal antibodies and delivered direct to their cellular targets. Many responses linked this idea to diagnosis rather than to treatment of disease. Many candidates wrote about immune responses and the role of antibodies in defence against disease instead of treatment of disease. Some candidates did not attempt to answer this question.

Question 2

(a) Most candidates answered this question well. Many knew that phospholipids with polyunsaturated fatty acids increased the fluidity of membranes, with a significant number of candidates referring to the looser packing of the fatty acid tails compared with the close packing of saturated fatty acid tails. However, few were able to describe the consequences of this in terms of maintaining the movement of substances across membranes, with many stating incorrectly that membrane transport would be increased. For example, many suggested that keeping the membrane fluid would increase the rate of osmosis. Few responses also stated that maintaining the fluidity maintains the movement of membrane proteins. Some candidates had difficulty expressing their ideas with the correct terminology. Some responses referred only to cholesterol and so gained no credit. Incorrect answers included references to phospholipids insulating the cells. Others stated that phospholipids store heat, food or energy to help survival of the plants through the winter.

(b) (i) There were many good answers to this question. Some candidates gained credit by describing monomers as repeating sub-unit molecules and gave glucose and/or amino acids as examples. Some thought that triglycerides were made up of amino acids or polypeptide chains. The main misconception was that triglycerides and phospholipids are monomers.

(ii) Many candidates gained full credit for this question. Weaker answers stated that triglycerides have three glycerols and phospholipids have only two or that phospholipids have phosphate instead of glycerol. Some candidates did not gain credit as they referred to two or three 'tails' without identifying them as fatty acids. Some responses referred to phosphorus rather than phosphate. Weaker responses described chemical properties rather than structural features.

(c) Many candidates had thorough knowledge of the principles of cell signalling and applied this to the unfamiliar context of thromboxane and its role in reducing blood loss. Common errors included confusing the events that occur after thromboxane is released from platelets with the events that occur before it is released and stating that smooth muscle constricts rather than contracts as a result of stimulation by thromboxane. Few stated that thromboxane travels in the blood. A significant number of candidates suggested that, in this example of cell signalling, the target was the artery wall rather than smooth muscle cells within artery walls. Some responses were very general or too vague to be awarded credit.

Question 3

(a)(i) There were very few suggestions to explain that the protein that gives the cloudiness to the solution is broken down into amino acids by Neutrase®. Candidates were told that Neutrase® is used to hydrolyse the proteins in solution. Therefore, credit was given only if it was stated that the hydrolysis results in amino acids. Amino acids are soluble so more light passed through the reaction mixtures as the protein was gradually hydrolysed. **Fig. 3.1** shows that in the reaction with water (the control), the absorbance almost reached zero after 100 s. This makes the time period long enough to see the progress of the hydrolysis reaction under the conditions used in the investigation. A significant number referred to the experiment being about Neutrase® absorbing light. Many referred to being able to see rates of reaction and others stated that, as the reaction continued, the absorbance increased. They also did not realise that more light was transmitted through the mixture as the protein substrate was broken down.

(ii) Some **c**andidates realised that very little hydrolysis occurred in reaction mixtures **A** and **B** because the absorbance decreased very little. They also appreciated that almost all of the protein was hydrolysed in reaction mixtures **C** and **D**. Good answers compared the results for **A** with the results for **B**, or the results for **A** against **D**, or between **C** and **D** in support of these points. Their analysis of the data led candidates to state that copper sulfate inhibits Neutrase® whereas potassium sulfate does not, and to suggest the mechanism of inhibition of the enzyme by copper sulfate. Weak answers often argued the opposite, that Neutrase® requires copper sulfate as some sort of activator and that no reaction occurs between Neutrase® and its substrate without it. Many suggested that the fastest reaction occurred when the absorbance remained constant rather than when it decreased steeply. Some candidates stated that copper sulfate changed the pH of the solution so that the enzyme did not function, whereas potassium sulfate did not. Others suggested that the copper sulfate or potassium sulphate solutions directly affected absorbance. Weaker candidates concentrated on using the graph to describe the results in each reaction mixture and needed to explain what effect the copper sulfate and potassium sulfate had on the activity of the enzyme. Many candidates interpreted the graph incorrectly, identifying the high absorbance as representing high activity of the enzyme and consequently did not gain any credit.

(b) Many candidates gained full credit. Candidates should make it clear that immobilised enzymes can work at higher temperatures than enzymes free in solution, rather than that they can withstand a range of temperatures. There were many instances where candidates stated ambiguously that the solution would not be contaminated by immobilised enzymes instead of focusing on the product being uncontaminated.

Question 4

(a) Many answers to this question did not make it clear that the daughter cell in **Fig. 4.1** had the ability to divide to produce more cells, which have the ability to divide and differentiate into any cell type in the shoot. Some candidates saw this question in limited terms and stated that the meristematic cell would form more companion cells and sieve tube elements, whereas others understood that meristematic cells in the shoot tip can form a wider range of specialised cells. Many simply thought that more and more meristematic cells would be obtained.

(b) The strongest responses showed evidence of careful study of the diagram of the development of the two cell types in phloem tissue. Many answers lacked the required detail shown on **Fig. 4.1**. Some candidates did not refer to the sieve tube element or to the companion cells in their answers, referring to phloem cells in general. A few gave exact descriptions of what could be seen in **Fig. 4.1**. Often, candidates did not describe what was shown in the diagram using simple terminology of cell structure and the names of the cell types as given at the end of **Fig. 4.1**. Many responses wrote about the cell cycle and mitosis.

(c) Many candidates described the peripheral cytoplasm of phloem sieve tube elements stating that there are few organelles present. This was related to reducing resistance to the flow of phloem sap. They also described the plasmodesmata between the sieve tube elements and companion cells and the flow of sucrose between them. Fewer candidates explained the roles of sieve plates and sieve pores. Some mentioned the cell surface membrane and its role in movement of water into sieve tube elements when sucrose is loaded at the source. Candidates often referred to features that are characteristic of xylem, not phloem. Many candidates stated that the sieve tube cells were empty, had no organelles or were dead and did not explain that they have peripheral cytoplasm that included some mitochondria. Many answers focused on the functions of sieve tubes without reference to the required structures. Some candidates did not restrict their answer to sieve tube elements and wrote about the function of companion cells as well.

(d) Many of the answers to this question stated that companion cells have many organelles compared to sieve tube elements but needed to go on to say how this benefited the sieve tube elements. Many candidates described how these cells load sucrose into sieve tubes and gained credit. Some answers did not make it clear that companion cells move sucrose from mesophyll cells in leaves, or from storage cells, and then move it into sieve tubes. Many answers described active transport in companion cells, but did not make clear the direction of movement of protons from the cells into cell walls. Some stated that sucrose is loaded into phloem rather than into sieve tubes. Few responses mentioned sources and/or sinks. Candidates should know that the movement of hydrogen ions out of the cytoplasm of the companion cell into the cell wall (apoplast) is an example of active transport. The force generated by the build-up of hydrogen ions is used to move sucrose from the cell wall to the cytoplasm of the companion cell against its concentration gradient. The movement of sucrose into the cells is an example of cotransport, so it is not strictly correct to state that it occurs by active transport.

Question 5

(a) Many candidates gained full credit here. If candidates did not use the term vessel they had to state that blood remained in three of the following structures: heart, arteries, veins and capillaries. A number omitted to mention ‘in one circulation’ or ‘in one circuit of the body’ when explaining double circulation and just stated that the blood travelled through the heart twice.

(b) (i) Where candidates did not gain full credit, common errors included naming **1** as the pulmonary artery, **2** as an atrioventricular valve and **3** as the right ventricle.

(ii) There were many good answers that made clear the reasons for the left ventricle having a wall thicker than that of the right ventricle. Candidates who wrote that the left ventricle pumped blood around the whole body, gained credit if elsewhere in their answer it was made clear that this excluded the pulmonary circulation. Credit was given for recognising that pulmonary capillaries are damaged by high pressure and that this could lead to a build-up of tissue fluid collecting in the lungs. Common errors were stating that **X** was an artery and **Y** was a vein or that **Y** was the right atrium, and to state that thicker walls were to withstand higher pressure. Very few used the terms pulmonary and systemic. Many knew that chamber **Y** generated high pressure, but did not explain why.

(c) There were many good descriptions of the coordination of the contractions of the heart. Some responses could have made it clearer that the atria contracted before the ventricles following the initiation of a heartbeat by the sinoatrial node. A common misconception was that during the cardiac cycle the left side of the heart contracts first followed by the right side. Some wrote a description of the events that occur in the heart during one cardiac cycle rather than how those events are coordinated by the conducting tissue: sinoatrial node, atrioventricular node and Purkyne fibres.

Question 6

(a) (i) There were many correct answers to this question. Although most candidates stated that 30% of the nucleotides contained guanine, not all explained their answer in terms of complementary base pairing. Similarly, some stated that there were equal amounts of adenine and thymine, but did not refer to base pairing to explain why.

(ii) Many candidates identified mitochondria as the location where DNA occurred in the cells of *Chorthippus brunneus*. Common incorrect answers were chloroplast, ribosome and cytoplasm.

(b) (i) The common error in this question was to give the base sequence in the tRNA molecule as GGTC. Some candidates did not attempt this question.

(ii) Many candidates named region **Q** on the tRNA molecule as the anticodon. Many then went on to state that the anticodon binds to a codon on mRNA. Some candidates did not include mRNA in their answer or did not state that anticodons and codons bind or form base pairs. These candidates often stated that an anticodon is complementary to a codon without giving further detail. Very few candidates completed their answer by stating that pairing between codon and anticodon ensures that the correct amino acid joins the growing polypeptide so ensuring the primary structure coded by the appropriate gene. Most referred to the amino acid carried by each tRNA as being specific and forming peptide bonds without further detail.

(iii) Many candidates knew that the region labelled **P** was the site of attachment of an amino acid.

BIOLOGY

Paper 9700/22
AS Level Structured Questions

Key messages

One difference between phloem sieve tube elements and xylem vessel elements is the fact that the sieve tube elements are living while the vessel elements are dead. This comparative feature is not an example of a structural difference, as stated by some candidates in **Question 1(d)**. The structure of the living phloem cell would be the features of peripheral cytoplasm and the presence of some organelles, contrasting with the structure of the dead xylem vessel element, which would be hollow, with no cell contents (no cytoplasm or organelles).

When describing the different ways that an infectious disease can be transmitted, candidates should make clear that they understand the difference between the disease and the pathogen that causes the disease. For example, a common error in **Question 4**, which was about cholera, was to state that water is contaminated by the disease, rather than stating that water is contaminated by the pathogen or by *Vibrio cholerae*. In addition, it is important for candidates to know the type of pathogen that is represented by the named organism. In **Question 4**, a number incorrectly thought that *V. cholerae* was a virus.

When considering the structure of a phospholipid, it is important to include the phosphate group plus the glycerol (phosphate head) and the fatty acid residues that form part of the molecule. It is not sufficient to say that a phospholipid has a hydrophilic head and two hydrophobic tails, as was stated by a number of candidates in **Question 5(b)**. Although this provides information about the nature of the different parts of the molecule, it does not give enough structural detail.

General comments

All syllabus topics were assessed in this paper. All questions apart from **Question 6** required candidates to draw from more than one syllabus topic and highlighted the need for candidates to be able to think across the syllabus when tackling some questions. When completing the paper, many made good use of the spaces provided to respond to questions and took notice of the level of credit that could be allocated when deciding how many different ideas to incorporate into their response. A very high level of competence was shown by a good proportion of candidates: this included a good understanding of the command terms used in the question and an ability to look back at information provided to help formulate a response. At the other extreme, some candidates lacked the ability to use correct scientific terminology and did not compose their answers to take account of the number of different ideas that should be included to be eligible for maximum credit. There were a number of instances where some correct biological knowledge was used for an answer that did not address the question topic and could not be credited. Examples of this were references to cell signalling in **Question 2(d)** and a description of the symptoms of sickle cell anaemia in **Question 3(d)**.

In **Question 3(d)**, candidates needed to bring together ideas about haemoglobin from three syllabus topics to answer an extended response. Here, the best accounts showed a good understanding of the central dogma and levels of haemoglobin structure by clearly separating their ideas: differences between alleles were explained, then differences in transcription and translation were covered, followed by the effect of these on the polypeptide and then the complete protein molecule.

In **Question 4 (c)(ii)**, candidates had to interpret a graph with two *y*-axes, and some did get these the wrong way around. When quoting data from a graph, candidates should check whether the figures seem sensible, for example quoting 560 000 countries and 18 cases in 2008 should have alerted candidates that they had made a mistake.

Question 6 frequently highlighted that many candidates could recall the principals of experimental method when investigating the progress of an enzyme-controlled reaction, but not all could demonstrate complete understanding of the results of the investigation.

Comments on specific questions

Question 1

(a) Most candidates knew that **Fig. 1.1** showed a stem and a high proportion gained the credit by giving an acceptable reason, for example by stating that the vascular bundles, or xylem and phloem, were arranged around the periphery or by stating that the xylem and phloem were not located in the centre of the section. Stating only that the xylem and phloem were in a ring, or that they were not star shaped, was not credited without further qualification about the location of the transport tissue. Some drew a sketch of where the location would be in a root, and this was helpful to gain the credit. Some incorrectly stated that the vascular bundles were arranged around the edge of the cell. Others cited the lack of root hair (cells) as their rationale for identifying the figure as a stem; as root hair cells are not present in all parts of the root, this was not creditworthy.

(b) It was not necessary to name the tissue concerned although many did identify the tissue as being of parenchyma cells. The role of the whole tissue or individual cells was accepted and many gained full credit. Most realised that the large central vacuoles of these cells were important and gave some good examples of storage of substances. Weaker responses gave incorrect reasons for support, such as thick cell walls. Some of the stronger responses explained how turgidity and storage of water in the vacuole would provide hydrostatic support for the stem, but this was not commonly seen. Reference to symplast and apoplast pathways were often given, sometimes following on from an incorrect identification of **Fig. 1.1** as a root.

(c)(i) Most knew the term to describe structure **B** and generally the spelling of vascular bundle was correct. 'Vesicle bundle' was the only relatively common mistake.

(ii) Candidates were knowledgeable of conversion factors and usually the correct answer was given. Some who did not gain credit could have benefited from studying their answer and making judgements about whether the size stated was a realistic estimate.

(d) The quality of response here was very varied. Some high-quality accounts used a sentence for each feature and made sure that the statement was comparative. A number gave most of the points expected and some constructed a comparison table where features compared were easy to identify. A very common error was to state that xylem vessel elements were dead and phloem sieve tube elements were living. Some did not go on to explain what this meant structurally. Care needed to be taken when comparing: stating that phloem had mitochondria but xylem did not was not enough to show understanding that xylem vessel elements had no contents at all. A misconception was to think that xylem did not have cellulose and only had walls made of lignin. Some candidates listed every organelle that they thought was found in the phloem: if this list included a nucleus then credit could not be given. Some suggested that having a companion cell was a structural difference, but as this is a separate type of cell, it cannot be considered part of a phloem sieve tube element.

Question 2

(a) Goblet cells were well known as structures associated with mucus. Fewer remembered that mucous glands were also present in the gas exchange system. Some were not precise enough and named main structures in the gas exchange system, such as the trachea and bronchus. Incorrect answers named cell structures such as the Golgi body or cilia.

(b) Information was provided in the question stem that mucin was present in vesicles ready for secretion from the cell. This allowed candidates to make links with the Golgi body and rough endoplasmic reticulum, and either structure was acceptable as a location of post-translational modification. Some named ribosomes but this was not credited, as it is only after the polypeptide has entered the lumen of the RER that glycosylation may occur. Others stated the cytoplasm.

(c) Deciding on the order of the stated processes was generally straightforward for all but those candidates who performed less well overall. Transcription and translation were usually stated in the correct sequence.

(d) The strongest responses used terminology stated in the syllabus, were concise when answering the question and gave a sequential account. Many candidates could have improved their response by:

- Avoiding use of the terms concentration of water or water concentration.
- Using the terms lower water potential and higher water potential rather than incorrectly stating lower water potential gradient or higher water potential gradient.
- Stating that water leaves the cell or crosses the cell surface membrane by osmosis rather than by diffusion.
- Stating clearly that water leaves the cell by osmosis, rather than just stating water moves to the area with the chloride ions by osmosis.

Some incorrectly suggested that the exit of chloride ions would cause water to move into the cell. There were a proportion of candidates who gave very good descriptions and explanations of the mechanisms by which chloride ions could leave a cell but were unable to gain credit as they did not answer the question posed. A number of candidates, some of whom did well overall, attempted to answer the question from the point of view of a cell signalling cascade triggered by chloride ions.

(e) Most candidates realised cells of the gas exchange system needed replacing, but to gain credit this idea had to be qualified with a reason. The importance of mitosis in tissue repair was well known but many candidates incorrectly stated that mitosis was important in repairing cells. Fewer referred to the need for the new cells to function in the same way as the cells they were replacing or to repair tissue so that it could still function effectively. Some were accurate in describing the importance of mitosis in producing genetically identical cells, although stating that mitosis produced identical cells was insufficient as this would mean that daughter cells would have exactly the same contents, which is not the case. Mitosis for growth was only credited when candidates showed a clear understanding that an increase in the size of the gas exchange system, by an increase in the number of cells, would only occur in childhood. Some referred to the role of mitosis in asexual reproduction, which had no links to this question. Others gave accounts of mitosis in immune system cells, or descriptions of the causes and types of damage sustained by the respiratory system, which were not relevant answers to this question.

Question 3

(a) Some candidates had no difficulty identifying the different blood cell types from the photomicrograph of a human blood smear. Although **E** was a monocyte, macrophage was accepted as a correct response. Macrophages have granular cytoplasm and mature from monocytes when these cells leave the blood stream to enter tissues.

(b)(i) Most candidates knew, or deduced, that leucocytes were formed in the bone marrow. Others understood that this meant that stem cells were present in the organ. Some candidates who understood that mutations were more likely to arise when a cell is replicating its DNA, added the information that cell division involving stem cells would be occurring. It was sufficient just to note that cell division would occur in the bone marrow. Statements referring to CLL and uncontrolled cell division of white blood cells were also credited.

(ii) Stronger responses made it clear that there were two very different causes of the increase in white blood cell count. When explaining the situation for measles, detailed explanations were given of how the immune response would lead to an increased number of lymphocytes as a result of clonal expansion. Stating that the immune system responds was not an alternative to using the key term 'immune response'. Others were too vague to be awarded credit, with statements such as 'the disease causes a lot of white blood cells to be produced'. For CLL, good answers explained that uncontrolled cell division occurs, rather than just stating that this was continued cell division. Fewer answers noted that the reason for uncontrolled mitosis was a mutation or gave other details such as an inability of cells to respond to cell signals.

(c)(i) Some candidates understood that this question was only about the passage of oxygen across the cell surface membrane of the red blood cell. These responses were likely to get full credit, noting that oxygen molecules were small enough to cross the bilayer, and were non-polar. Fewer gave correct details of the mechanism of transport, diffusion across the phospholipid bilayer, with quite a number writing about carrier or channel proteins. A proportion gave accounts of gas exchange between the alveolus and the red blood cell or gave a general statement of oxygen diffusing into the red blood cell and describing oxygen uptake by haemoglobin, none of which answered the question posed.

(ii) The introduction to this question explained to candidates that the partial pressure of oxygen is lower at sea level than at a high altitude. The stronger candidates began their response by explaining the effect of this on the uptake of oxygen in the lungs, rather than unnecessarily stating that at high altitude the partial pressure of oxygen in the atmosphere is lower. Many were able to gain some credit for a statement concerning haemoglobin. There were a number who could have gained more credit by showing knowledge that red blood cells contain haemoglobin: here their responses were entirely about red blood cells not being saturated with oxygen or not being able to transport as much oxygen. Some candidates were careful to give unambiguous explanations, making it clear that they understood an increase in red blood cells would not improve the saturation of haemoglobin molecules, but would provide more haemoglobin to collectively transport the same quantity of oxygen as at sea level. Quite a few gained credit for this point by using the term 'compensate' or 'compensation'. There were many who did not gain credit by stating that more oxygen was carried when there was an increase in red blood cells. Some responses included descriptions of, or only wrote about, altitude sickness.

(d) There was a very wide range in quality of response here, with some extremely knowledgeable and clear, comprehensive accounts as well as some either very confused answers or answers that only addressed part of the question. Some could have made clearer the difference between the alleles and the amino acid change in the polypeptide. Statements such as 'The Hb^A allele has glutamic acid and is CTT but the Hb^S allele is valine which is hydrophobic' did not show evidence of understanding despite the use of some correct terminology. Most were able to give some detail about a change in amino acid and a change in the structure of β-globin or haemoglobin. Few candidates noted that: the substitution of one base for another resulted in different mRNA codons; the change was in the sixth amino acid or DNA triplet (or mRNA codon); haemoglobin molecules with the valine-for-glutamic acid change formed fibres (became sticky) with other molecules. Care was needed when describing the change to the levels of structure in the protein. A change in the quaternary level of protein structure could only occur with the whole haemoglobin molecule and not the single β-globin polypeptide. A good proportion knew that a change in structure decreased the solubility of the molecule and the ability to transport oxygen. A common error was to describe the molecule, rather than the red blood cell, becoming sickle shaped.

Question 4

(a) Candidates did not need to have prior knowledge of the structure of a *Vibrio cholerae* cell, but needed to apply their knowledge of prokaryotic cell structure to complete **Fig. 4.1**. Many completed the diagram with care and to a high standard. Credit was not awarded for the cell wall or cell surface membrane unless another line had been drawn in. Some candidates correctly labelled 'circular DNA' yet drew a number of unconnected lines or coiled shapes with a clear start and end. Others indicated that the main circular DNA of the cell was known as the plasmid. Maximum credit could not be awarded when a structure found only in eukaryotic cells was added to the diagram. It was quite common to see a nucleus or mitochondrion added to the cell. A number of candidates did not use the diagram provided as instructed, and drew their own version of *V. cholerae*, which could not gain full credit. Some weaker responses drew both bacterial and viral structures, usually by drawing the cell wall but labelling it as 'protein coat' or 'capsid'.

(b)(i) Most candidates completed a correct calculation, although not all gave the answer to the nearest 0.1%.

(ii) A number of candidates correctly focused their response on why some countries had high case fatality rates of cholera. Many wrote answers about high rates of transmission and number of cases of cholera and did not suggest explanations as to why proportionately more people with cholera were dying from the disease. Answers about improper treatment or lack of ability for individuals to pay for treatment did not gain credit: rehydration treatment is provided freely by non-governmental organisations and is effective and easy to administer.

(c)(i) Most had a good understanding of the relationship between a natural disaster such as an earthquake and a cholera outbreak. Some used the term 'polluted' rather than 'contaminated' when describing the supply of drinking water and others used the term 'waste' instead of 'sewage'. These could not be credited unless the response contained additional correct detail.

(ii) There were some excellent responses to this question, with many gaining full credit. It was far more common to see answers that described or compared trends for the two sets of results than commented on reasons for the trends seen, despite being provided with the information in the introduction. A few realised that the initial outbreak of cholera in 2010 had increased to epidemic proportions in 2011. Some candidates read off values from the wrong *y*-axis when attempting to provide numerical values to support a point. Good answers gave trends rather than describing year-to-year changes. Some candidates were too vague with their comparative statements: 'low number of cases' could not in this instance be considered the same as 'lowest (or least) number of cases' and similarly 'highest' or 'most' should have been used instead of 'high'.

Question 5

(a) Some candidates needed to check that all the examples of biological molecules given in **Fig. 5.1** had been included in the completed **Table 5.1**. Many did well to gain full credit. For most of the molecules listed, correct completion of the task was based on knowledge of the molecules and an understanding of the terms. Only glycine and α-globin required knowledge to be applied.

(b) Many candidates were able to establish that the phosphate head of the phospholipid molecule is hydrophilic in nature and that the fatty acid tails are hydrophobic. The strongest answers indicated how these properties allowed a bilayer to form naturally and noted both sides of the bilayer, with the phosphate heads facing both the external surroundings of the cell and the internal solution. It was not enough to state that the tails face away from water as this could just form a monolayer rather than a bilayer. A few very good answers included detail of the hydrophobic interactions between the fatty acid tails. Some included small labelled diagrams to support their response which enabled further credit to be awarded in some cases. There were candidates who described two heads per phospholipid molecule, used the term 'lipid tail' to mean 'fatty acid tail' or confused 'hydrophilic' with 'hydrophobic'.

Question 6

(a)(i) Many candidates had no problems with this question. For those who were not familiar with this practical, sufficient information was provided in the question stem. 'Amount' of oxygen was not credited. Although a graduated inverted cylinder was shown in **Fig. 6.2**, many suggested counting bubbles. This was not credited as the reaction would be very fast and bubbles would appear too quickly to be counted. In addition, when the reaction was at its most vigorous the bubbles would collect and bubble size would not be uniform. Some explained that the volume was measured by the decrease in the water level in the cylinder as it was being displaced by the oxygen, which was acceptable. As the equation was given in **Fig. 6.1**, 'gas' was accepted for 'oxygen'. Some candidates stated that hydrogen was produced. Some did not mention that the volume should be measured at timed intervals or over a period of time. A few suggested time intervals that were impractical, such as measuring every second. Some described the experiment, which was not required, but then gained credit when details of a graph that could be drawn were included. Only a handful of responses noted that the initial displacement of water would be air that had been displaced by the addition of the hydrogen peroxide solution.

(ii) Most responses indicated that cutting the same volume of potato as the first experiment into smaller pieces would mean that there would be an increase in surface area. There were quite a few, however, who thought the opposite. For maximum credit candidates needed to show an understanding that more enzyme would be available for the reaction. Many incorrectly stated that enzyme would only be on the surface of the potato tissue rather than being released from the damaged potato tissue and dispersed throughout the peroxide solution. Hence, suggestions that more hydrogen peroxide would be able to contact the enzyme remaining on the potato tissue surface were seen. Some indicated that the potato tissue was the substrate and the hydrogen peroxide the enzyme.

(b) Some candidates drew curves that were standard for how temperature affects the activity of an enzyme, reflecting a doubling in rate of reaction with every 10 °C rise in temperature until the optimum, with a steep decrease as denaturation occurs. Many drew bell-shaped curves that were more like the curves seen for the effect of pH on the rate of reaction. Frequently, candidates needed to show more clearly that the curve decreased more steeply at temperatures above the optimum than it increased at temperatures before the optimum. Some drew curves that were symmetrical about the optimum yet had labelled the curve beyond the optimum as denaturation. Very weak responses drew the curve for substrate concentration.

BIOLOGY

Paper 9700/23
AS Level Structured Questions

Key messages

When describing the different ways that an infectious disease can be transmitted, candidates should make clear that they understand the difference between the disease and the pathogen that causes the disease. For example, a common error in **Question 3**, which was about cholera, was to state that water is contaminated by the disease, rather than stating that water is contaminated by the pathogen or by *Vibrio cholerae*. It is also important for candidates to know the type of pathogen that is represented by the named organism. In **Question 3**, a number incorrectly thought that *V. cholerae* was a virus.

One difference between phloem sieve tube elements and xylem vessel elements is the fact that the sieve tube elements are living while the vessel elements are dead. This comparative feature is not an example of a structural difference, as stated by some in **Question 4(a)**. The structure of the living phloem cell would be the features of peripheral cytoplasm and the presence of some organelles, contrasting with the structure of the dead xylem vessel element, which would be hollow, with no cell contents (no cytoplasm or organelles).

In **Question 4(c)(ii)**, a number of candidates were confused between active transport and cotransport when describing the movement of sucrose into a companion cell. The movement of hydrogen ions out of the cytoplasm of the companion cell into the cell wall (apoplast) is an example of active transport. The force generated by the build-up of hydrogen ions is used to take sucrose in against its concentration gradient from the cell wall to the cytoplasm of the companion cell. This is an example of cotransport and it is not strictly correct to state that this is active transport of sucrose, although the term secondary active transport can be used. Hydrogen ion movement can be described as facilitated diffusion as the protons are moving down their concentration gradient through the cotransporter membrane protein.

General comments

All syllabus topics were assessed in this paper. There was good evidence that many candidates were able to draw together information from different parts of the syllabus to answer whole questions and some part-questions. Generally, good use of the space provided was made when responding. Many candidates were very well prepared and paid good attention to the command terms used in the question. Some candidates could have taken more guidance from the credit that was allocated to each part-question to help them judge the detail and quantity required when answering. It is also good practice to look back at information provided to help formulate a response and to take time to read the questions carefully.

Question 2 was based on gas exchange in humans and transpiration in plants. In **Question 2(b)(ii)**, a proportion of candidates wrote about gas exchange in the lungs rather than suggested how the alveoli are adapted for gas exchange. Similarly, in **Question 2(c)**, some wrote about the movement of water in the leaf and transpiration rather than how the arrangement of cells in the leaf contributed to the loss of water by transpiration.

Much of **Question 5** required candidates to handle information and to apply knowledge and understanding. It was important to have made note of the introductory sentence of **Question 5(a)** when answering part **(a)(ii)**. Quite a few did not make use of this information. A good answer to **Question 5(b)(ii)** needed both descriptions of the data provided in **Table 5.1** and explanations for the data. Many candidates only gave descriptions and so only answered part of the question.

Comments on specific questions

Question 1

(a) A circle placed around any one nucleotide was able to gain credit. The most common error was to draw a circle around a base pair, although there were quite a few candidates who only circled a phosphate joined to a deoxyribose.

(b) Candidates were asked to name the base pairs at **X**, so it was not sufficient to give C and G. The majority who knew the correct answer also knew that the two bases were joined by three hydrogen bonds.

(c) Most knew that, during DNA replication, the two strands of the double helix separate (5) after hydrogen bonds break (3). A few candidates were then able to deduce the next event in the sequence would be the formation of hydrogen bonds (4), as this occurs when the free activated DNA nucleotides become positioned opposite their complementary nucleotide on the DNA template strand. However, most candidates thought that the next event was DNA polymerase forms a phosphodiester bond (1).

(d) Many gained some credit with the knowledge that telomeres help to prevent the loss of genes during DNA replication. It was not correct to state that telomeres prevent the loss of genetic material as during each replication some telomeric DNA is lost. Far fewer stated that telomeres permit continued replication. Some confused the role of telomeres with the role of the enzyme telomerase, which is not on the syllabus.

Question 2

(a) The calculation of the actual diameter of the lumen of the bronchus was usually correct and most candidates followed the instruction to write down the formula used.

(b) (i) A high proportion of candidates realised that the general tissue lining the air spaces of the alveoli was epithelial tissue. To gain credit the type of epithelial tissue needed to be named and far fewer knew this to be squamous epithelial tissue. A very common incorrect answer was to state elastic fibres or elastic tissue.

(ii) For those gaining credit, most noted the thin alveolar walls providing a short diffusion distance for the respiratory gases. A large surface area was also credited, with the clearest statements linking this to the collectively large surface area provided by many alveoli. Some did not realise that the spherical shape of an alveolus offers the lowest surface area to volume ratio of a three-dimensional structure and therefore large surface area linked to the shape of a single alveolus was not credited. A number noted the presence of elastic fibres and some of these gained credit with the idea of stretch and recoil during ventilation. Using the terms relax and contract was not credited.

(c) The strongest responses used knowledge of transpiration and loss of water in conjunction with knowledge of the arrangement of cells in the leaf. Most other candidates gave descriptions of varying detail about the pathway of water between the xylem in the leaf and the external atmosphere. For these, some credit was gained for knowledge that spongy mesophyll cells have air spaces between them and that a water potential gradient built up allowing water vapour to diffuse out through stomata to the atmosphere. It was rare for a link to be made between evaporation and large internal surface area provided by the spongy mesophyll cells or for a statement about the location of the sub-stomatal air spaces.

(d) (i) Many candidates performed well on this question and generally values were extracted and quoted correctly. Some converted the the time of day shown in **Fig. 2.2** to a.m. and p.m. values. While this was credited, it was a source of error for some when the conversion was incorrectly made.

(ii) One or more acceptable factors were named by a number of candidates but this needed to be qualified by what would have caused a decrease in transpiration rate. For example, stating that light intensity changed did not necessarily explain a decrease. Some made plausible suggestions of a xerophytic response. Others made a statement about a xerophytic feature that would only be a design to keep the rate of water loss continually low. Some references to stomatal closure were not credited as they were too vague and did not fit in with the pattern and/or timings shown in **Fig. 2.2**.

Question 3

(a) Completing **Table 3.1** correctly was straightforward for many. Most knew that both cell types had cell surface membranes and knowledge of ribosomes in both cell types was apparent, but many thought that a *Vibrio cholerae* cell and/or the intestinal epithelial cell had a large permanent vacuole and that only *V. cholerae* had organelles bound by a double membrane.

(b) There were some well-expressed, perceptive accounts of the methods that could be used to prevent the spread of cholera. Many had organised their response very well and wrote about the ways in which individuals could protect themselves so the disease would not be passed on, how the infrastructure of communities could be improved to protect citizens and methods that could be used to prevent spread from people with the disease. All the expected points were seen, with the most common ideas focusing on drinking water and sewage systems. Almost all candidates knew that cholera was transmitted by a faecal-oral route.

(c) (i) Many candidates were able to use the information provided and use **Fig. 3.1** to deduce that gp120 of the human immunodeficiency virus would be complementary to the CD4 receptor of helper T-lymphocytes and that binding would allow entry of the virus into the host cell. Some erroneously described cell signalling events, whereas others suggested that binding would allow the virus to directly kill the host cell. The glycoprotein gp120 was often incorrectly described as a receptor. Some stated that gp120 was an antigen that triggered the immune response on binding to CD4.

(ii) The strongest answers explained directly the effect of a low helper T-lymphocyte count. Others gained full credit if they described the role of the cells and then acknowledged that fewer helper T-lymphocytes meant that this response would be reduced. For those who just gave a full account of the role of the cells in the production of antibodies, only minimal credit could be awarded. Some incorrectly wrote about the role of killer T-lymphocytes and weak responses suggested that helper T-lymphocytes produced antibodies.

Question 4

(a) This was a straightforward question to answer for candidates who knew the structure of xylem vessel elements and phloem sieve tube elements. A number used well-constructed comparative sentences where others wrote a clear sentence about one cell type followed by a sentence about the other cell type. Some gave more than two differences which gained no additional credit. Some of the weaker responses described the differences in the function of the two cell types or reversed their descriptions of the cell types.

(b) This question assessed knowledge of the biochemical test for non-reducing sugars. Good answers explained the use of hydrochloric acid in producing the two reducing sugars and followed this up by explaining how the Benedict's test could then be used. Weak responses suggested that the acid was used to extract the sucrose from the phloem sap. A common error was to describe sucrose as not being a reducing sugar, rather than to state that it was a non-reducing sugar.

(c) (i) To gain credit, candidates needed to state more than a general cellular role of the mitochondrion and the ribosomes. **Fig. 4.1** could be used as a prompt to guide candidates to the specific roles of these cell structures in the companion cell in the loading of sucrose into a phloem sieve tube element. Many did not use the diagram and the lack of detail meant that credit could not be awarded. Some incorrectly thought that the ribosomes were also involved in ATP production.

(ii) The best responses were sequential and began with the pumping out of hydrogen ions into the cell wall (or apoplast) and finished with a good description of the cotransport of sucrose by the hydrogen ions. Some knew the term cotransport but did not make it clear that sucrose moved through the cotransporter protein at the same time as the hydrogen ions. Some described the diffusion of sucrose through plasmodesmata into the phloem sieve tubes, which did not answer the question.

Question 5

(a) (i) Most candidates correctly described the function of cell **Y** or stated phagocytosis. It was not necessary to name cell **Y** as a neutrophil.

(ii) Good answers used the correct terminology and correctly identified the area outside the cell as having a lower water potential than inside the cell. The term concentration gradient should not be used when applied to water. Most knew that water left the cell and some could have gained further credit by stating that osmosis occurred. Candidates who did not make the link with the fact that the blood cells had been placed in a solution of sodium chloride made unlikely suggestions as to why red blood cells were crenated. Some suggested that the cells were examples of the sickle shape associated with sickle cell anaemia.

(b) (i) Many were able to give the correct calculated value or a correctly rounded value. An answer rounded down to 13.5% was not accepted.

(ii) The quality of response for this question was very varied. The strongest candidates noticed that the population living at the highest altitude did not have the highest mean red blood cell count. Others only made a comparison between populations **A** and **D** and stated that red blood cell count increased with altitude. Credit was given if candidates showed an understanding that the partial pressure of oxygen in the atmosphere decreased with altitude. Some also made a correct reference to haemoglobin in their explanation. A few gave valid suggestions to explain the differences in results between populations **B**, **C** and **D**.

(c) Most candidates gained some credit here. It was important to continue the response through to the lack of haemoglobinic acid formation (or to the lack of hydrogen ions to bind to haemoglobin), which some candidates did. Most others concentrated on explaining the effect of an inhibitor on the reaction catalysed by carbonic anhydrase to gain partial credit. It was not enough to only state that the inhibitor binds to the enzyme at a site other than the active site, as this did not finish the explanation of why the ability of the enzyme to function would be affected.

Question 6

(a) This was well done by the majority of candidates. Where full marks were not achieved, the most common errors were giving **M** as the valve preventing backflow into the ventricle and **T** as the chamber that pumps blood to the lungs.

(b) The short-term effects of nicotine on the cardiovascular system were well known and many were able to gain full credit. The effect of nicotine on the brain and the long-term potential effects of the compound were not required.

(c) (i) Candidates who gained credit applied knowledge of the stages of the cell cycle. As the stage following the end of mitosis is cytokinesis some realised that this would not occur if the cell cycle stopped too early. Some knew that there would be a difference in the DNA or chromosomes but found it difficult to explain what the difference would be, such as stating that these cells would still have both chromatids from each chromosome. Some tried explanations involving ‘sets of DNA’ but did not make it clear what a ‘set’ was. Many thought that all the adult myocytes still had the ability to continue with the cell cycle and suggested that if an adult myocyte had a cell cycle that had stopped at the end of mitosis, it would not be able to divide again.

(ii) The best answers applied knowledge of the importance of mitosis and wrote about myocyte replacement and cardiac muscle tissue repair. A common error was to state that mitosis repairs cells. More vague answers wrote about how the heart would not be able to function properly.

BIOLOGY

Paper 9700/31
Advanced Practical Skills 1

Key messages

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

When drawing the observable features of cells in a specimen, the drawings must have the correct proportions and shape. Plant cell walls should be drawn with two lines, with a middle lamella between adjacent cells and the relative thickness of the cell walls should be in the correct proportion to the size of the cells.

Candidates should carefully consider the wording of questions to ensure that they identify and address the requirements. For example, when instructed to show working, all steps in a calculation should be clearly displayed.

General comments

In general, candidates demonstrated a good understanding of the skills required in this paper. The majority of candidates showed they were familiar with the microscope and demonstrated good drawing skills. The majority of candidates were able to suggest appropriate controls such as replacing the enzyme / plant extract with the same volume of water or denaturing the enzyme / plant extract by boiling.

Comments on specific questions

Question 1

(a) (i) The majority of candidates correctly assessed the level of risk and gave a valid reason.

(ii) The majority of candidates organised their results by presenting a ruled table, with correct headings and units, where appropriate. The most common error was not to include pH in the independent variable column or to count the number of drops instead of measuring the volume.

(iii) The majority of candidates were able to state the independent variable as pH.

(iv) Many candidates were able to suggest a suitable optimum pH using their results with a valid reason, for example, the pH with the least volume of **P** added. A common error was to suggest the pH with the largest volume of **P** added.

(v) Most candidates were able to suggest a source of error and gained credit for it. Many recognised that measuring the volume was difficult as they were unable to read the volume because of the dark colour of **P**. The majority referred to the drops leaving the syringe being different sizes. Some referred to multiple drops coming out the same time. Multiple drops alone was not sufficient to gain credit as they had been directed to practise releasing one drop at a time from the syringe before starting the experiment. This, however, was allowed if they justified their answer by stating that **P** came out faster than water or the syringe was sticking or different pressure may have been applied to the syringe.

(vi) Many candidates were able to suggest improvements to the investigation and most suggested increasing the number of different pH buffers used. The better candidates were able to specify a narrower range either side of their suggested optimum pH. Many suggested using different apparatus to measure the volume of **P**; the more able candidates suggested that the apparatus should have smaller divisions so gained credit for this.

(b) (i) Most candidates used the headings given in the table to correctly label the axes. Some candidates labelled the incorrect axis or gave incomplete headings. Most candidates used a scale of 10 to 2 cm for the *x*-axis and 2 to 2 cm for the *y*-axis. Many candidates plotted the points exactly with a small cross or dot in a circle, and some drew a sharp, clear, ruled line, accurately connecting the points. The most common error was drawing lines which were too thick or not ruled to the centre of the point.

(ii) Most candidates answered correctly. The most common error was to omit the units in their answer.

(iii) Many candidates were able to provide an appropriate explanation for these results. Some candidates did not state the temperature at which the volume of oxygen was at its highest from their graph. Those candidates who quoted data from the graph to justify their explanation gained credit for it.

(iv) Many candidates were able to describe an appropriate control. The most common error was to state variables that needed to be controlled instead of suggesting a control.

Question 2

(a) (i) Credit was awarded to candidates whose drawings were of an appropriate size and did not include any cells. Stronger answers gained credit for carefully following the instructions and drawing the appropriate amount of detail within the section in the correct proportions.

(ii) Most candidates drew the required number of cells and labelled a cell wall correctly. Many used a sharp pencil to draw clear thin lines that were continuous. The most common error was to draw cells that were too small or lines that were not continuous.

(b) (i) Some candidates used the letters **Q**, **R** and **S** and correctly annotated Fig. 2.1. A common error was to annotate the xylem vessels as air spaces or have label lines that did not touch the difference described.

(ii) The majority of candidates correctly used the scale bar and the line **Z** to calculate the actual width of the root. The better answers showed all of the steps in the working and used appropriate units.

BIOLOGY

Paper 9700/32
Advanced Practical Skills 2

Key messages

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

Candidates should be able to describe any control experiments to make sure that it is the independent variable that is affecting the dependent variable.

Control experiments can be of two types:

- Where all factors are kept identical to the experimental set-up except that the value of the independent variable is zero. For example in Question **1(a)(vi)**, where water is used instead of a test solution.
- Where the control is to confirm that it is an organism causing a particular effect, by leaving out or replacing the organism with non-living material. For example, using sterile glass beads instead of an invertebrate in a respirometer.

General comments

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

Comments on specific questions

Question 1

(a) (i) Many candidates were able to complete **Table 1.2**, showing four correct concentrations of sucrose in the table in addition to 10.0 percentage concentration of sucrose solution. Many candidates correctly stated 8.0, 6.0, 4.0 and 2.0 percentage concentration of sucrose solution with the correct volumes of **S** and **W**, making a total of 5 cm^3 for each concentration to use in the investigation.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger responses included an appropriately detailed heading for the independent variable (percentage concentration of sucrose) and the dependent variable (time / seconds). The majority of candidates gained credit for recording results for at least four concentrations of sucrose solution and showing that the highest concentration of sucrose solution had the shortest time for the first appearance of a colour change. The higher achieving candidates recorded all the times as whole seconds.

(iii) The majority of candidates stated their result for **U** in seconds.

(iv) Many candidates correctly estimated the concentration of sucrose in **U** and stated whether **U** had been taken from the phloem of a plant treated with fusicoccin by reasoning that the concentration of **U** was either between 5.5% and 7.5% or outside this range. The most common error was giving a reason based on the time taken for Benedict's solution to show the first appearance of a colour change rather than referring to the concentration of sucrose in **U**.

(v) The majority of candidates were able to suggest ways to change the independent variable in order to have more confidence in their estimate of the concentration of sucrose in **U**. Many candidates correctly suggested preparing more concentrations of sucrose solution close to the estimate for **U** with narrower intervals between each concentration. Some candidates gained credit for suggesting that the concentrations of sucrose could be prepared using proportional dilution.

(vi) Many candidates gained credit for stating that plant **G** was treated with 10 cm^3 of water instead of fusicoccin solution as it was acting as a control.

(b) (i) The majority of candidates drew the graph, using the headings from the table to label the axes. The stronger responses used scales of 50.0 to 2 cm for the *x*-axis and 5.0 to 2 cm for the *y*-axis, labelling at least every 2 cm. Many candidates also plotted the points precisely with a small cross or dot in a circle and drew a ruled line using a line of best fit.

(ii) Many candidates were able to use their graph to find the time when the rate of mass flow was 20 $cm^3 min^{-1}$ and showed on the graph how they determined their answer. The most common errors were to give the answer in seconds rather than minutes and not showing on the graph how the answer was determined.

(iii) The majority of candidates correctly stated that the effect of fusicoccin was to increase the rate of mass flow.

(iv) Some candidates correctly referred to fusicoccin binding to receptors of the companion cells, increasing the active transport of hydrogen ions, the role of cotransporters and the transport of sucrose via plasmodesmata.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells or shading and used most of the space provided. The stronger responses gained credit for drawing at least two layers of tissue and showing only three vascular bundles. Many candidates gained credit for drawing the correct proportion of the vascular bundles in relation to the other tissues and also gained credit for including other observable tissues and drawing at least three layers of tissue. Most candidates used a label line to correctly identify the epidermis.

(ii) Credit was awarded to candidates whose drawings were made using lines which joined up precisely and used most of the space provided. Many candidates drew two epidermal cells and two adjacent, touching cells below the epidermis, with two lines for the walls of the cells. The most common error was to draw lines that did not meet up precisely. Most candidates used a label line to identify the cell wall of a cell.

(b) (i) Many candidates correctly identified the organ shown in **Fig. 2.1** as a stem and gained credit for stating that the vascular bundles were located around the outside, close to the epidermis.

(ii) The majority of candidates gained credit for measuring the length of the vascular bundle using line **Z** within an acceptable range. Many candidates measured **Z** in millimetres and showed this figure divided by 20. Most candidates calculated the actual length of the vascular bundle correctly to the appropriate degree of accuracy and used the correct units.

(iii) The majority of candidates correctly stated that the apparatus is a graticule or a stage micrometer.

(c) Many candidates listed at least two observable differences between **M1** and **Fig. 2.1** such as **M1** had fewer vascular bundles than **Fig. 2.1** and **M1** had scattered vascular tissues while in **Fig. 2.1** the vascular tissue was located towards the epidermis.

BIOLOGY

Paper 9700/33
Advanced Practical Skills 1

Key messages

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

Candidates should be aware that the wording of questions often indicates how the candidate should respond. The word 'explain' may imply reasoning or some reference to theory. In **Question 1(c)(ii)**, when asked to suggest an explanation for the results between pH2 and pH6, the candidate needed to make clear in their answer that they had stated why something happens, such as referring to the shape of the active site of pepsin changing after pH2 leading to the substrate being unable to bind to the active site and fewer enzyme-substrate complexes being formed.

General comments

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

Comments on specific questions

Question 1

(a) (i) Many candidates were able to show how to carry out a serial dilution, stating the correct concentration below each beaker (10.00%, 1.00%, 0.10%, and 0.01%) and transferring 1 cm^3 of the previous concentration to the next beaker and adding 9 cm^3 of distilled water to each beaker.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger responses included the heading for percentage concentration of milk (**M**) and the heading for symbol or colour. The majority of candidates gained credit for recording the results for at least four concentrations of milk. Many candidates recorded results which showed that the higher the percentage concentration of milk the deeper the shade of purple. The strongest responses recorded the colours as symbols.

(iii) Most candidates correctly recorded a result for **X** using one of the symbols in the key.

(iv) Some candidates correctly estimated the concentration of protein in **X** from their results based on the fact that 100% **M** contained 12 g of protein in 100 cm^3.

(v) Most candidates correctly stated that a significant source of error was the difficulty of judging the exact shade of colour.

(vi) The majority of candidates were able to suggest three improvements to the investigation so that a more accurate estimate of the concentration of protein in **X** could be obtained. Many candidates correctly suggested preparing more concentrations of milk close to the estimate for **X** with narrower intervals between each concentration. Some candidates correctly suggested using a colorimeter and using the data to draw a graph. A few candidates noticed that the milk concentrations changed colour over time and suggested that carrying out the test for **X** at the same time as the milk concentrations would help give a more accurate estimate of the concentration of protein in **X**.

(b) Most candidates used the headings given in the table to correctly label the axes. Some candidates labelled the incorrect axis or gave incomplete headings. Most candidates drew bars of equal width and distance apart on the *x*-axis, used a scale of 1 to 2 cm for the *y*-axis and plotted each bar accurately. The strongest responses drew ruled lines for the bars so that the vertical lines joined with the horizontal lines precisely. The most common error was drawing lines which were not ruled.

(c) (i) Many candidates correctly described the trend shown in **Fig. 1.4** by stating that as the pH increased the percentage mass of the protein remaining increased.

(ii) Many candidates correctly explained that between pH2 and pH6 the activity of the pepsin gradually declined. They correctly suggested that, as a result of the active site changing shape, the substrate could no longer bind to the active site resulting in fewer enzyme-substrate complexes forming. Many candidates correctly suggested that the enzyme had become denatured. The most common error was to give a description of the graph rather than give an explanation of what was occurring to the pepsin as the pH increased.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells or shading and used most of the space provided. The higher achieving candidates gained credit for following the instructions and drawing the whole of the section. Many gained credit for drawing at least two layers of tissue and drawing the bulges accurately on the outer surface. Many candidates gained credit for drawing the correct proportion of the inner vascular area in relation to the other tissues. Most candidates used a label line to correctly identify the epidermis.

(ii) Credit was awarded to candidates whose drawings were made using lines which joined up precisely and used most of the space provided. Many candidates drew four adjacent touching cells from the central region of the stem, with two lines for the walls of the cells. The most common error was to draw lines that did not meet up precisely. Many candidates were credited for showing at least one cell which had at least five sides. Most candidates used a label line to identify the cell wall of a cell.

(b) (i) The majority of candidates gained credit for measuring the scale bar and the line **Z** within an acceptable range. Many candidates measured the scale bar in millimeters and showed this figure multiplied by 1000 to convert into micrometres before dividing by 317. Many candidates correctly calculated the magnification of **Fig. 2.1** in this way then divided their measurement for **Z** by this magnification to calculate the actual width of the root and used the correct units.

(ii) The stronger candidates organised the table into three columns, with one column for features, one headed **K1** and one headed **Fig. 2.1**. Many candidates listed at least three observable differences between **K1** and **Fig. 2.1** such as **K1** had fewer layers of tissues than Fig**. 2.1**, **K1** had a smooth, continuous outer layer while **Fig. 2.1** had a rough discontinuous outer layer and cells of **K1** were larger than the cells of **Fig. 2.1**.

BIOLOGY

Paper 9700/34
Advanced Practical Skills 2

Key messages

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

When drawing the observable features of cells in a specimen the drawings must have the correct proportions and shape. Plant cell walls should be drawn with two lines, with a middle lamella between adjacent cells and the relative thickness of the cell walls should be in the correct proportion to the size of the cells.

Candidates should carefully consider the wording of questions to ensure that they identify and address the requirements. For example, when instructed to show working, all steps in a calculation should be clearly displayed.

General comments

In general, candidates demonstrated a good understanding of the skills required in this paper. The majority of candidates showed they were familiar with the microscope and demonstrated good drawing skills.

Comments on specific questions

Question 1

(a) (i) Some candidates were able to explain that using the higher magnification lens would allow them to observe the different states of plasmolysis more easily. Many appreciated the need for a large sample size from different fields of view so that enough cells were counted.

(ii) The majority of candidates organised their results by presenting a ruled table with correct headings. The candidates that displayed the numbers of cells in each of the four stages of plasmolysis for each sodium chloride concentration gained the most credit.

(iii) The majority of candidates correctly identified **S2**, **S3** and **S4**.

(b) Most candidates drew the required number of cells. Many used a sharp pencil to draw clear thin lines that were continuous. Some candidates correctly labelled the cell surface membrane of one cell. The most common error was to draw cells that were too small or with lines that were not continuous or to label the cell wall as the cell surface membrane.

(c) (i) Many responses referred to the pattern of water movement either into the potato tissue (below 0.4 / $mol\,dm^{-3}$) or out of the potato tissue (above 0.4 / $mol\,dm^{-3}$). A large number of candidates did not refer to the movement of water and just described the change in length of the potato tissue. The better answers also stated that there was no net movement of water at 0.4 / $mol\,dm^{-3}$.

(ii) Most candidates were able to explain that the water potential was higher in the sucrose solution than in the potato cells, so water moved into the potato cells by osmosis. The most common error was not to refer to the potato cells or the direction of water movement.

(iii) Most candidates were able to suggest three variables that needed to be standardised. Some candidates gained credit for describing how they were standardised by suggesting the apparatus they would use.

Question 2

(a) (i) Many candidates were able to describe an appropriate control. The most common error was to state variables that needed to be controlled instead of suggesting a control.

(ii) Many candidates suggested the use of a drying agent and gained credit for this. The most common error was to suggest the use of a fan which may reduce the humidity but also changes the movement of air.

(iii) Most candidates recorded their measurements of the water remaining and correctly calculated the water lost.

(iv) The majority of candidates answered this question correctly from their results.

(b) (i) Most candidates gained credit for showing their workings. Candidates also gained credit for not including the anomalous result in their calculation of the mean.

(ii) Most candidates used the headings given in the table to correctly label the axes. Some candidates labelled the incorrect axis or gave incomplete headings. Most candidates used a scale of 20 to 2 cm for the *x*-axis and 20 to 2 cm for the *y*-axis. The strongest responses plotted the points precisely using a small cross or dot in a circle and accurately connected the points with a ruled line. The most common error was drawing lines which were too thick or not ruled to the centre of the point.

(iii) Most candidates described the correct trend.

(iv) Most candidates answered correctly. A common error was to read the value off the incorrect axes.

(c) Many candidates drew a plan diagram that was an appropriate size and did not include any cells. The strongest candidates carefully followed the instructions and drew the appropriate amount of detail within the section in the correct proportions.

(d) The majority of candidates correctly counted the number of eyepiece graticule units and used these to calculate the actual width shown by the line **X**-**Y**. The better answers showed all of the steps in the working and used appropriate units.

BIOLOGY

Paper 9700/35
Advanced Practical Skills 1

Key messages

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

Candidates should be aware that the wording of questions often indicates how the candidate should respond. The word 'explain' may imply reasoning or some reference to theory. In **Question 1(b)(iii)**, when asked to explain the increase in the concentration of protein in blood plasma between day 0 and day 6, the candidate needed to make clear in their answer why something happened, such as referring to the role of plasma cells and the production of antibodies, which were made of protein.

Within an investigation, candidates should be able to identify anomalous results and remove them before beginning calculations, e.g. when calculating means. In **Question 1(b)(i)**, the reading for person 2 at 8 days was anomalous and should have been discounted when calculating the mean at 8 days.

General comments

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

Comments on specific questions

Question 1

(a) (i) Many candidates were able to carry out a serial dilution, stating the correct concentration below each beaker (0.50%, 0.25%, 0.125%, and 0.0625%) and transferring 10 cm^3 of the previous concentration to the next beaker and adding 10 cm^3 of distilled water to each beaker.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for percentage concentration of protein (**P**) and the heading for colour. The majority of candidates gained credit for recording the results for at least four concentrations of protein. Many candidates recorded results which showed that the higher the percentage concentration of protein the deeper the shade of purple. The stronger responses recorded all the colours as letters.

(iii) The majority of candidates stated a colour for **U**.

(iv) Some candidates completed **Fig. 1.2** correctly. Credit was given to those candidates who put the label **U** on **Fig. 1.2** to show an estimate of the concentration of protein in **U**. The most common error was to omit showing the concentrations of protein that had been prepared in step 1.

(v) The majority of candidates were able to suggest ways to change the independent variable in order to have more confidence in their estimate of the concentration of protein in **U**. Many candidates correctly suggested preparing more concentrations of protein close to the estimate for **U** with narrower intervals between each concentration. Some candidates gained credit for correctly suggesting that the concentrations of protein could be prepared using proportional dilution.

(vi) Many candidates correctly suggested that a colorimeter could be used to measure the concentration of protein in **U** more accurately.

(b) (i) Some candidates correctly completed **Table 1.3** by calculating the mean concentration of protein in blood plasma at 8 days. Since there was an anomalous result for person 2 this should have been omitted from the calculation.

(ii) Most candidates used the headings given in the table to correctly label the axes. Some candidates labelled the incorrect axis or gave incomplete headings. The higher achieving candidates used scales of 2.0 to 2 cm for the *x*-axis and 20.0 to 2 cm for the *y*-axis, labelling at least every 2 cm. Many candidates plotted the points accurately and joined the points precisely or drew a curved line passing through all the plots. The most common errors were not using the correct scale and drawing a line which did not go through each plot.

(iii) Many candidates correctly explained that the increase in the concentration of protein in blood plasma between day 0 and day 6 was caused by the presence of a foreign antigen or a bacterium. The stronger responses stated that plasma cells produced antibodies and that antibodies were made of proteins. The most common error was to give a description of the graph rather than give an explanation of what was causing the increase in the concentration of protein in blood plasma.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells or shading and used most of the space provided. The higher achieving responses followed the instruction to draw the largest bulge. Many candidates gained credit for drawing at least two layers of tissue and showing only the midrib. Many also gained credit for drawing the correct proportion of the vascular area in relation to the midrib and for showing subdivision of the vascular tissue. The best responses also included other observable tissues and drew at least three layers of tissue. Most candidates used a label line to correctly identify the upper epidermis.

(ii) Credit was awarded to candidates whose drawings were made using lines which joined up precisely and used most of the space provided. Many candidates correctly drew four adjacent, touching cells from the epidermis of the leaf, with two lines for the walls of the cells. The most common error was to draw lines that did not meet up precisely. Many candidates were credited for showing at least one cell which was longer than it was deep. Most candidates used a label line to identify the cell wall of a cell.

(b) The majority of candidates gained credit for measuring the depth of the midrib using line **X** within an acceptable range. Many candidates measured **X** in millimetres and showed this figure divided by 14. Most candidates calculated the actual depth of the midrib correctly to the appropriate degree of accuracy and used the correct units.

(c) Many candidates listed at least three observable differences between **L1** and **Fig. 2.2**, such as **L1** had more vascular bundles than **Fig. 2.2**, **L1** had more midribs than **Fig. 2.2** and **L1** had fewer stomata than **Fig. 2.2**.

BIOLOGY

Paper 9700/41
A Level Structured Questions

Key messages

- Candidates should practise analysing data from tables and drawing conclusions from this.
- Candidates should focus their response according to the command words and key demands of the question to ensure that they answer the question.

General comments

This paper produced a wide range of marks and discriminated well. Some candidates achieved very high levels of credit by linking ideas from their knowledge to the question context. Many candidates showed good background knowledge of syllabus ideas and some ability to select and order information and make sense of new data. Weaker candidates confused basic biological terms and had difficulty understanding the demands of some questions.

Comments on specific questions

Section A

Question 1

(a) (i) Most candidates answered correctly. Common incorrect answers included G protein, carrier protein and 'integral'.

(ii) Many candidates interpreted the diagram of the cell membrane correctly and identified the transport proteins accurately. Errors included calling **B** a hydrogen pump rather than hydrogen ion or proton pump, and stating that **C** was voltage-gated. The name aquaporin was required for **D**.

(b) Many answers scored full credit and correctly described the cell wall pH decreasing, expansins being activated and either bonds breaking between cellulose microfibrils or the cell wall expanding. A common misconception was that expansins are enzymes. Other mistakes included referring to cellulose myofibrils. It was not well-known that the bonds that break between cell wall components are hydrogen bonds.

(c) Most candidates gained full credit for explaining the decrease in water potential and water entry by osmosis. A few candidates showed faulty reasoning in focusing on ion movement changing the electrical potential of the cell membrane.

Question 2

(a) (i) The correct answer, continuous, was the most common. Incorrect answers included discontinuous, normal, bell-shaped and stabilising.

(ii) The interaction of genes and environment to produce the pattern of variation seen for IPD was poorly known and explained. Strong answers mentioned polygenes, additive effects and the role of the environment in affecting gene expression, or a specific environmental factor such as diet affecting the development of IPD. Weak answers discussed the causes of variation in meiosis or provided explanations involving natural selection.

(b) (i) Many candidates gave the name regulatory gene, but fewer explained that the *PAX3* gene codes for a transcription factor that binds to the promoter to help RNA polymerase action. Candidates commonly misnamed the PAX3 protein as a repressor protein and argued that it would stop RNA polymerase action, despite the information given in the question stem to the contrary. Some candidates struggled to apply their knowledge of gene regulation within a new context.

(ii) Descriptions of microarray analysis were highly variable in quality. There were many excellent answers showing clear understanding of the preparation of fluorescently tagged cDNA from the mRNA of target cells and the grid-like appearance of single-stranded probes of known genes on the microarray chip. Hybridisation, washing-off of unbound cDNA and visualisation of fluorescence with a laser scanner were also described. There were also many confused answers, with DNA taken from cells instead of the mRNA needed to show which genes are being expressed, DNA being labelled with GFP genes instead of fluorescent dye molecules and probes added to the chip instead of cDNA.

(iii) The strongest candidates were able to synthesise a reasoned explanation of how large phenotypic differences can depend on differential gene regulation of a similar suite of genes. Good answers used the information that PAX3 protein controls other genes and that in the chimpanzee more PAX3 protein will cause a different pattern of expression of these other genes than in humans. The strongest candidates integrated all the information given to explain that the relatively smaller IPD of the chimpanzee shown in the photo was the result of increased PAX3 expression.

Question 3

(a) Although the cross was straightforward, many candidates did not gain full credit due to choosing inappropriate symbols, not specifying carefully enough or correctly what each symbol represented and not giving a ratio of phenotypes at the end. Many erroneously gave a ratio of genotypes of 1:2:1.

(b) The strongest answers described the flow of biochemical changes from a DNA base change to an incorrect protein active site fully and using the correct terminology. Answers that gained full credit also often covered both missense and nonsense mutations. Incorrect ideas included silent mutations (which would not produce a non-functioning protein) and frameshift mutations (which could not be caused by a base substitution).

(c) Strong answers moved from the idea of only needing one allele to produce an inhibitor to the consequences, integrating other concepts from across the question as a whole. Weaker answers generally repeated the question information without explaining how EOPD would result.

Question 4

(a) Most candidates scored full credit on this question.

(b) The majority of candidates correctly identified the electron transport chain or oxidative phosphorylation as the destination for reduced NAD but references to NAD being a coenzyme for dehydogenase enzymes were rare. Some candidates had difficulty explaining the idea of a hydrogen carrier molecule. This could be improved by the inclusion of the ideas of NAD being a hydrogen atom carrier and the H atoms splitting into protons and electrons at the electron transport chain.

(c) (i) The correct answer of six was infrequent. While candidates would be expected to know that six CO_2 molecules are produced from one molecule of glucose, many struggled to provide the correct answer when given the context of specific production sites (the link reaction and Krebs cycle).

(ii) Strong answers were clear about the effect of the named chemical, e.g. carbonic acid would decrease pH. Weaker answers did not name the chemical they were referring to or specify its precise effect, or they simply named carbonic acid as 'toxic' or 'harmful' without elaborating.

Question 5

(a) (i) Most candidates correctly predicted that the mean hind limb length of *A. sagrei* would decrease. Some referred to selection for short legs or an increase in alleles for short hind limbs rather than directly answering the question. Candidates describing in detail how natural selection would act on the lizards did not gain credit if no reference was made to how this changed the mean of the phenotypic feature.

(ii) The 'random' idea in the question prompted many candidates to discuss achieving representative results or removing bias. Correct answers showed an awareness of variation in the mean limb length of the collected individuals placed on the different founder islands.

(b) This was a demanding question in which candidates were asked to refer to two figures to describe and explain results. Strong answers described the two contrasting trends for the source island and for the founder islands and named the types of selection involved, stabilising and directional. They also identified the selection pressure, the beneficial trait that was selected for and how it aided survival and reproductive success. Weaker candidates lost credit by not making clear that limb length decreased on the founder or experimental islands and by describing results for all seven islands individually without pointing out the overall trend or offering explanations. Discussions of perch diameter did not always identify this as the selection pressure. Candidates made good use of the correct term 'selection pressure' as opposed to 'selective pressure.'

(c) Many answers made correct reference to allopatric speciation. A minority contradicted this by stating that sympatric speciation also occurred. Descriptions of geographical separation and reproductive isolation often did not identify the entities – populations, or the lizards on different islands – that were separated. Some stated that there was no breeding between islands for example, rather than between lizards on the islands. It was rare to see a reference to genetic differences accumulating over time but the idea of different mutations and selection pressures on different islands was often well explained. Two important errors were common: the misconception that different selection pressures *cause* mutations and that genetic drift is when selection changes allele frequencies.

(d) Strong answers identified that the starting population was small with a small gene pool and high chance of inbreeding depression. Some candidates suggested the populations would be less able to adapt but did not state to what, for example a changed environmental condition, new selection pressure or new disease. The idea that a small population was more likely to be wiped out by another natural disaster or hurricane was credited.

Question 6

(a) Many candidates described the process of genetic engineering well, naming the key enzymes and tools such as restriction endonucleases, ligase, vectors, promoters and marker genes. Most could apply their knowledge within the context of the production of insect resistant MON810 and some showed awareness that this strain is an example of Bt maize. Responses were less effective at describing the insertion of the recombinant plasmid containing the new gene into maize cells or saying that the gene would be expressed in maize to make the toxin. Mistakes included obtaining the new gene from maize itself, or directly joining the new gene to maize DNA without using a vector.

(b) This question was poorly answered for two reasons. Firstly, some candidates were unable to use the supporting explanation to make sense of what the data showed, for example, not realising that the data showed how much the amount of maize *harvested* would change if there was a decrease or increase in the *cultivation* of maize. Secondly, many candidates responded to 'social and ethical implications' by stating recalled ideas, when the question required that the data be used to suggest implications. As the modelling clearly showed that increasing GM crop use to 88% of a country's total would increase yield, while banning GM crops would decrease yield, the social and ethical implications were overall positive. However, many candidates' responses focused on super weeds and allergies.

Question 7

(a) (i) Strong answers described the trends succinctly by drawing attention to the similarities and differences between them and by quoting accurately from the graph with both *x* and *y* coordinates and units. Answers consisting of two separate stepwise descriptions with no parallels or contrasts picked out were less likely to gain all of the credit available.

(ii) Most candidates gave a correct answer. Candidates should take care to spell pancreas correctly.

(ii) Most candidates correctly answered negative feedback.

(b) (i) Well-prepared candidates knew the names of the two enzymes on the dipstick.

(ii) Candidates were knowledgeable here but some stated a disadvantage for the dipstick, rather than an advantage.

(c) Most responses scored some credit here, with full credit being rarely awarded. The influence of insulin in causing glycogenesis, increasing the respiration of glucose and decreasing blood glucose concentration were well known, although the terms 'of glucose' and 'concentration' were ideas missed by some candidates. Some also knew that insulin decreases gluconeogenesis and many noted that in order to control blood glucose concentration insulin binds to receptors on the principal target tissues of liver, muscle and adipose tissue. Modern understanding of the effect of insulin on these target tissues shows that only in muscle and adipose tissue do extra GLUT 4 transport proteins get added to the cell surface membrane to increase the cell's permeability to glucose. In liver cells a specialised hexokinase (glucokinase) phosphorylates glucose to maintain a steep diffusion gradient for glucose to pass into the cell via GLUT 2 proteins. A few candidates were careful to distinguish between these different mechanisms in the different tissues.

Question 8

(a) Most candidates earned full credit for selecting area **C** and explaining that it was more biodiverse because it had a higher number of species and habitats.

(b) Candidates generally selected the correct area, area **A**, but were unable to explain why it was likely to be affected the most if the environment changed. A correct explanation focused on the small number of species in this area and how fluctuations in the number of one species would have a larger impact on other species than if they interacted in a more complex, biodiverse food web.

(c) A large number of candidates restated the idea of conserving biodiversity – preventing extinctions, saving species, maintaining food webs – rather than offering reasons why it is important to do this.

Question 9

(a) Many candidates gained only limited credit on this question. Knowledge of the principles of limiting factors was patchy, as was the practical application of the theory to growing crops in a glasshouse. The best known facts were the names of the three main factors that affect the rate of photosynthesis and the ideas of using lamps, heaters and ensuring adequate irrigation in the glasshouse. As the question asked candidates to explain how knowledge of limiting factors is used, background explanation of the biochemistry of photosynthesis did not gain credit.

(b) This question was answered well by many candidates. Points that were sometimes omitted were the binding of spindle fibres to centromeres and the orientation of the second spindle apparatus in meiosis II at right angles to the first. Common errors included not being specific about whether they were describing single chromosomes, bivalents or paired chromatids, and making mistakes about the order in which processes occurred. Some were confused about when cells become haploid during meiosis, e.g. writing that cells at the end of meiosis I are diploid. Candidates needed to be clearer about the distinction between chromosome numbers and chromatid numbers.

Question 10

(a) The functioning of a cholinergic synapse was described very well by most candidates. The main errors were not specifying ions correctly (e.g. omitting the word ion or giving incorrect symbols), saying that *vesicles* leave the presynaptic neurone by exocytosis and describing ions as moving *into* a membrane rather than through the membrane into the cytoplasm.

(b) Knowledge of DCPIP as a redox indicator and how to make a suspension of intact working chloroplasts was poor. Candidates did better in describing how to control variables in their experiment and how to conduct replicates, find a mean and calculate the rate of photosynthesis. Explanations of the biochemistry of photosynthesis did not answer the question so did not gain credit. Candidates did not always have a clear idea of the colour change that occurs when DCPIP is mixed with the chloroplast suspension in the dark and how the colour changes with exposure to light.

BIOLOGY

Paper 9700/42
A Level Structured Questions

Key messages

Candidates should consider the number of marks available when answering each question. This provides an indication of the number of separate points that a candidate will need to make or the level of detail that will be expected.
Candidates should plan their use of time to ensure that they can engage effectively with all questions.

General comments

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

Comments on specific questions

Section A

Question 1

(a) The structures in the cross section of a myelinated neurone were, in general, correctly named. Responses identifying **A** as myelin were not specific enough. A number of candidates incorrectly identified **B** as the nucleus or simply repeated the information already provided in the question and identified **B** as a neurone. Very occasionally, responses were the wrong way around.

(b) The meaning of saltatory conduction and its effect on the transmission of a nerve impulse were well understood by the majority of candidates. Most stated that the impulse, or action potential, would jump from node to node, thereby increasing the speed of transmission. Some also provided detailed accounts to explain why depolarisation is only possible at the nodes. Few candidates went on to consider effects on local circuits and how these effects would affect the speed of transmission.

(c) There were some excellent accounts as to how sea snail toxin would prevent the generation of an action potential in the postsynaptic neurone. Full responses outlined the step-by-step consequences of exposure to the toxin to develop a coherent explanation that linked the initial exposure to the inability to generate action potentials in the postsynaptic neurone.

A number of candidates incorrectly referred to the exocytosis of vesicles, rather than the neurotransmitter, or stated that ions would enter the presynaptic or postsynaptic membranes. Although the stem of the question stated that the synapse was cholinergic, some candidates did not identify acetylcholine as the neurotransmitter.

A small minority of candidates simply described the process of neurochemical transmission, rather than addressing the question by considering the effect of the toxin.

Question 2

(a) (i) The responses of some candidates referred to types of speciation, rather than patterns of variation.

(ii) The majority of candidates correctly answered this question. Some candidates provided responses that were contradictory.

Incorrect responses often referred to mutation. While mutation does generate variation, mutation is non-directional and cannot explain, on its own, improved survival. Some candidates did not name a process, instead giving lengthy descriptions about how to improve tank conditions.

(b) Many candidates referred to the environmental conditions in the tank without linking these to how the phenotype of fish would be affected. Others linked relevant environmental features of the tank to differences in phenotypes of captive fish, without describing what these differences were. With no further explanation, such responses were too vague.

A significant number of candidates incorrectly interpreted this as a question about speciation and gave answers relating differences between the two environments to different selection pressures on allele frequencies. These candidates did not address the requirements of the question.

(c) (i) Overall, candidates were able to describe the process of microarray analysis quite well. A good number of candidates showed a clear understanding of the steps involved and many of these candidates were able to describe specific details of experimental technique.

Some candidates incorrectly referred to extraction of DNA, rather than mRNA, and a number of these described a role for restriction enzymes in the process.

When considering the application of the microarray analysis, the majority of candidates did not relate the process that they described to the context of this question: a comparison of gene expression between the two samples. Many responses implied that the microarray analysis described here reveals differences in the presence of genes in the genome, rather than differences in the pattern of gene expression.

(ii) Responses were of variable quality, with the majority of candidates confusing the processes of eukaryotic gene control and prokaryotic gene control. The prokaryotic *lac* operon was frequently used as an example, although this question specifically related to control of gene expression in eukaryotes.

Some candidates knew the term transcription factor but were unable to describe its role correctly, or its interactions with promoters and the binding of RNA polymerase.

A number of candidates incorrectly referred to gibberellins and DELLA proteins, although this question was about fish.

Some students misunderstood the context completely and, instead, wrote about dominant and recessive alleles or artificial selection. A minority of candidates did not attempt the question.

(d) (i) Few candidates were able to address this question effectively. Most candidates did not recognise the significance of keeping the two groups of fish in the same environmental conditions.

(ii) The majority of candidates did not specifically take into account the information in the question about wound healing. Better responses that did consider changes in wound healing and the immune response often did not go on to say how these were better for the fish.

Question 3

(a) This question required candidates to use their syllabus knowledge and understanding to outline the general principles of genetic engineering in an unfamiliar context. Relatively few candidates considered the source of the gene or how the gene could be introduced to the soybean genome. Few explained the final outcome in terms of gene expression.

Several candidates described the process of selective breeding, which was not directly relevant for GTS 40-3-2.

(b) Candidates generally found this question to be demanding. Where data was interpreted correctly, candidates recognised that GM soybean had the potential to increase overall yield. Good responses demonstrated higher order thinking by describing the social implications of increased or decreased yields in terms of food supply and cost, effects on potential profit, or on future herbicide use.

The information provided in the table was often misinterpreted. Many answers concentrated on trying to explain the figures, rather than providing an interpretation of the social and ethical implications of growing GM soybeans. Other answers largely ignored the data and gave general discussions on the topic.

Question 4

(a) The majority of candidates completed genetic diagrams in which parents and their gametes were correctly identified. Offspring phenotypes were usually correctly shown and linked to the expected genotypes.

Several candidates expressed the final answer as a ratio rather than as a probability.

A very small number of candidates incorrectly attempted to provide a genetic explanation based on a dihybrid cross or a sex-linked cross.

(b) (i) Many candidates were able to explain the difference between the product of a missense mutation and the product of a nonsense mutation. Overall, the effect of a nonsense mutation was better understood.

(ii) Many candidates were able to provide effective explanations.

(c) Candidates were able to provide a variety of valid reasons. Some incorrectly referred to inbreeding depression.

Question 5

(a) (i) Many candidates correctly labelled the glomerulus. The position of the lumen was less clearly appreciated, with some candidates labelling the surrounding convoluted tubules.

It was not always clear to which structure the candidates' label lines were pointing.

(ii) Most candidates were able to name the structure as the basement membrane. A few incorrectly suggested the basal membrane. Podocyte was a fairly frequent incorrect response.

(b) This question required a good understanding of the effect of the differing diameters of afferent and efferent arterioles on the process of ultrafiltration. Few candidates understood that a decrease in the lumen diameter of the afferent arteriole, or an increase in the lumen diameter of the efferent arteriole, would both lead to a decrease in the glomerular filtration rate.

(c) The mechanism of reabsorption of glucose in the proximal convoluted tubule was well explained only by the stronger candidates. Most candidates recognised the roles of facilitated diffusion and co-transport in the reabsorption of glucose, but fewer considered the link to the sodium-potassium pumps. Specific details were often lacking. For example, references to GLUT proteins were rare.

Less able candidates often suggested that sodium ions were pumped into the lumen of the proximal convoluted tubule.

(d) Most candidates were able to provide at least one of the features of a proximal convoluted tubule cell that adapt it to its function. The presence of microvilli to increase the surface area for reabsorption was the most frequent correct response.

Descriptions of relevant features were often too vague. For example, many candidates who appreciated the need for mitochondria or transport proteins in membranes, referred only to their presence rather than the need for large numbers.

Similarly, explanations often lacked specific details. For example, ATP synthesis was frequently omitted when considering mitochondria, and transport proteins were not always linked to specific molecules or ions.

Many candidates described the tight junctions between proximal convoluted tubule cells as a feature to prevent leakage of filtrate. Some incorrectly stated that these would prevent fluid or molecules from entering the cells.

Question 6

(a) Very few candidates were able to state the general theory of evolution. Many candidates used the term evolution in their answers and, as a result, simply restated the question.

(b) The strongest candidates were able to use the information provided to develop effective responses within the given context. Many candidates described general principles of evolution, often in detail, that were not related to the example given. Others simply repeated the information provided. Such responses did not fully address the requirements of the question.

(c) This question was answered fairly well. The majority of responses identified similar selection pressures and the need to find food. Some made a link to avoiding predators. A very small percentage of candidates correctly referred to convergent evolution.

A number of candidates referred only to one organism, usually the octopus, and so did not address the requirements of the question.

Some candidates wrote that octopuses and mammals were closely related, despite the information in the question stating that this was not the case. Some of these suggested that octopuses were mammals.

(d) (i) Most candidates were able to use correct terms to state a correct answer. A number of candidates considered that 600 million years ago could be considered to be recent.

(ii) Many candidates were able to make relevant comments, but few complete answers were given. Most candidates recognised the link between similarities in amino acid sequences and a close evolutionary relationship but not all expressed this in clear terms. Very few answers commented on comparing sequences or relating sequence divergence to the passage of time (e.g. molecular clock).

Some candidates discussed DNA and comparison of nucleotide sequences instead of amino acids.

Question 7

(a) Most candidates understood that there is a level of interaction within ecosystems. Many referred to the presence of a community of organisms and the importance of biotic and abiotic factors. Not all candidates recognised that an ecosystem includes all of the organisms present.

Few candidates were able to provide a full and coherent definition of the term ecosystem.

(b) Many candidates were able to recall the correct scientific term for each of the definitions provided.

Habitat was occasionally given incorrectly as the term matching both the first and third descriptions. Some candidates confused biotic factors and abiotic factors.

Question 8

(a) The process of oxidative respiration was well understood, with the majority of candidates being able to place each stage in the correct sequence.

The most frequent error was to reverse the order for the production of ATP and the formation of water.

(b) Many candidates were able to state all of the correct locations.

Some candidates stated that the cytoplasm was the correct location for pyruvate, despite being asked for the location in the mitochondrion. Other candidates could not recall the correct term for the intermembrane space. A small number of candidates incorrectly made reference to chloroplast structures.

Section B

Question 9

(a) Candidates found it difficult to develop complete and coherent responses. Details provided were often insufficient. For example, many responses omitted to refer to a suitable range of temperatures or considered how temperature could be controlled, although this was central to the investigation. A number of candidates described the use of a lamp at different distances from the plant as a means to control temperature, suggesting confusion with a practical investigating the effect of light intensity.

Few candidates considered control of factors other than temperature, such as how to maintain constant light intensity or carbon dioxide concentration.

Candidates often did not indicate how a suitable variable could be measured to assess the rate of photosynthesis, such as oxygen production. Where measurement was described, this was not always related to time. Without relating measurements to time, a calculation of rate is not possible.

Not all candidates considered the need to repeat the experiment and to calculate mean rates at different temperatures to increase the validity of the results.

(b) Candidates were aware of what gives rise to degraded habitats but most were unable to provide suggestions for the actions needed to restore them. Answers often incorrectly focused on measures for preserving threatened species of animals or plants in terms of zoos or national parks, or banning the activities which gave rise to the degraded habitats.

Valid suggestions were narrowly focused on replanting trees and, very rarely, the removal of alien species or litter. Few responses included named examples. The most frequently mentioned were the Amazon Forest, the mangroves of the Sundarbans or the waters of the Arabian Sea.

Question 10

(a) This was a well-answered question. The majority of candidates were fully aware of the inhibitory effects of progesterone and oestrogen on the release of FSH and LH from the anterior pituitary gland, with fewer responses stating that this was a negative feedback mechanism. Inhibition of the development of the Graafian follicle was not always identified but prevention of ovulation was well understood, as were the thickening of cervical mucus and the reduced development of the endometrium. Some candidates correctly referred to the use of synthetic hormones, since these act for longer and give rise to a high concentration in the blood.

(b) Most candidates appreciated the flow of events leading to speciation that follows geographical separation of a species into separate populations. Responses were frequently detailed. Examples of geographical barriers were often omitted.

BIOLOGY

Paper 9700/43
A Level Structured Questions

Key messages

Candidates should ensure that their intended responses are communicated clearly and effectively. Where candidates are asked to use data provided in tables, graphs or diagrams, it is important that responses refer to the data. The data should not simply be quoted, but used to support statements, identify patterns and trends or provide evidence for conclusions, as applicable. Examples of such questions include **Questions 2(b)(i)**, **3(b)(i)**, **4(b)(i)**, **4(b)(ii)** and **6(a)(ii)**.

General comments

Most candidates were able to engage with the questions to develop relevant responses. Candidates found **Questions 2(b)(ii)**, **3(b)(i)**, **3(b)(ii)**, **3(c)**, **5(b)** and **6(b)(ii)** particularly challenging.

It is important that candidates use the correct biological terminology in their responses. For example, in **Question 5(b)**, candidates were expected to use the terms ultrafiltration and collection duct correctly. Candidates should also be careful when choosing between quantity terms such as volume and concentration, to ensure that their choice of term matches the intended meaning.

Candidates need to carefully note the requirements of each question. For example, in **Question 8(b)**, respiration in anaerobic conditions and respiration in aerobic conditions both need to be compared to explain the difference in ATP yield. Simply listing what happened in each process separately does not address the requirements of the question.

Comments on specific questions

Section A

Question 1

(a) Very few candidates were able to identify all locations correctly.

(b) This question was well answered by most candidates. The majority recognised that a voltage-gated channel would open when there was an action potential or a change in potential difference (voltage). A number of candidates used incorrect terminology to describe the change in voltage.

(c) While many candidates noted that acetylcholinesterase was an enzyme involved in the breakdown of acetylcholine, only a minority explained the importance of this in removing acetylcholine from its binding sites on the postsynaptic membrane to allow repolarisation or in recycling acetylcholine.

(d) Most candidates noted that synapses ensure that transmission of action potentials occurs in only one direction. Some also noted that synapses enabled an interconnection of nerve pathways and were involved in memory and learning.

Question 2

(a) Many candidates were able to describe phenotypic features characteristic of albinism. Some identified features such as eye colour that would be different for a person with albinism without describing how this feature would be different. Such responses were too vague.

(b) **(i)** The majority of candidates found this question challenging. Many responses did not make use of data from Fig. 2.1 to show that inheritance of ocular albinism is sex linked.

(ii) Only a minority of candidates were able to provide fully detailed responses. Most did not use symbols for alleles that reflected that the gene is X linked and some did not link the offspring genotypes to the correct phenotypes.

(iii) Candidates who made good use of relevant terminology such as frameshift mutation, primary structure, tertiary structure and active site or binding site were often able to develop comprehensive responses. Some candidates also correctly considered the implications of a base mutation leading to a premature STOP codon.

A number of candidates confused protein terminology with DNA terminology.

(iv) Most candidates were able to provide a valid reason for having the test.

Fewer candidates were able to provide a valid reason against taking the test. Many considered that having the test might lead to stress if the result was positive, due to concern for future health implications. These candidates had not noted the information provided in the question that the disorder is present from birth and non-progressive. Furthermore, carrier females do not have symptoms.

Question 3

(a) **(i)** Many candidates correctly identified the type of variation shown by mean cilia length.

(ii) Most candidates were able to provide appropriate suggestions for harmful environmental factors to explain the difference between the two curves on Fig. 3.1.

(b) **(i)** Only the more able candidates considered the role of transcription factors in switching on genes. Most candidates correctly referred to Fig. 3.2 to give an example of how one of the genes was responsible for switching on a number of other specific genes.

A common confusion was the use of prokaryotic gene control terms like operators, operons and repressor proteins.

(ii) The majority of candidates found this question challenging. A small number of candidates were able to provide a coherent account of microarray analysis.

(c) This was another challenging question. A few candidates were able to suggest that researchers could find molecules or drugs that blocked the receptors to avoid stimulating dangerous responses.

Question 4

(a) Many candidates were able to outline the main steps in genetic engineering. Some candidates provided specific details relevant to this context by suggesting a suitable source for the gene of interest. Valid suggestions included insect-resistant plants or the soil bacterium *Bacillus thuringiensis*.

Full responses included references to marker genes and promoters and recognised that the gene of interest has to be inserted into the rice genome (rather than the whole plant) in such a way that it can be expressed.

(b) **(i)** Effective responses limited explanations to consideration of the data in Table 4.1, as required by the question.

Some candidates quoted figures from the table without explaining implications of the data. A large number of candidates answered incorrectly in the context of growing more GM crops.

(ii) Most candidates did not make use of the data in Table 4.2 to assess the environmental implications of a ban on growing GM crops.

Candidates making use of the data in Table 4.2 were able to address the question effectively by referring to habitat loss and increased emission of greenhouse gases.

Question 5

(a) There was a great deal of variation in the accuracy of the labelling by candidates.

(b) This was a challenging question based on knowledge of homeostasis. Some candidates recognised that there would be more ultrafiltration and therefore a greater volume of urine produced. Very few considered changes to the reabsorption of water in the collecting ducts or a possible role for ADH.

(c) Many candidates were able to accurately describe the effect of a decrease in the water potential of the blood on the hypothalamus and posterior pituitary gland. Fewer were able to describe the effect of ADH on the collecting duct. A significant number of candidates knew that aquaporins were involved but few provided further relevant details such as their location or change in number.

(d) Very few candidates were able to deduce the consequences of increasing the number of aquaporins in the cell surface membrane of cells in the distal convoluted tubule.

Question 6

(a) **(i)** The majority of candidates were able to interpret the information given to derive the correct answer.

(ii) Many candidates identified the relevant theories and developed responses based on the implications of selective advantage, including changes in allele frequencies. The most effective responses were coherent with successive steps linked together logically and made good use of biological terminology.

Some candidates used incorrect phrases, such as 'the alleles are more likely to survive'.

(b) **(i)** Some candidates correctly referred to numerical methods to assess the difference between DNA sequences, such as number of base differences or percentage of bases that are different. The most effective responses went on to discuss how the size of these differences related to evolutionary divergence and the likelihood that new species had evolved.

Not all candidates referred to comparison of base or nucleotide sequences in DNA.

(ii) Most candidates correctly recognised that mtDNA is inherited from the mother alone. Some recognised other advantages, such as a higher mutation rate than nuclear DNA and the existence of multiple copies per cell, allowing easier extraction of useful quantities of DNA.

Question 7

Most candidates successfully completed this question, correctly identifying the missing terms in the passage.

Question 8

(a) Responses to this question were variable. Candidates were more confident in sequencing the stages following glycolysis than the stages of glycolysis.

(b) Most candidates recognised that under anaerobic conditions oxidative phosphorylation does not occur and that this significantly limits the yield of ATP to that released from glycolysis.

Some candidates recognised that ethanol is produced but few linked this to the question by stating that ethanol is still energy rich.

A large number of candidates did not explain the difference in ATP production, as required, but instead listed the stages that occur in aerobic respiration.

Section B

Question 9

(a) A minority of candidates developed full responses by directly linking each detail of chloroplast structure to its function.

Several candidates wrote down what they knew about photosynthesis rather than answering the question.

(b) Very few candidates accurately described how chromatography could be used to separate chloroplast pigments.

Question 10

(a) Many candidates provided effective responses that were set out in a logical way with good use of relevant terminology and detailed descriptions. Some candidates included description of many of these stages but did not link these in a coherent sequence. A number of candidates incorrectly referred to release of hydrogen ions from reduced NAD, rather than release of hydrogen atoms.

Not all candidates clearly indicated the direction of pumping of hydrogen ions across the inner membrane and the subsequent diffusion of these ions back across the membrane through ATP synthase.

(b) Effective responses often made use of a diagram to show a simple respirometer and linked this to an accurate description of the methodology.

Not all candidates provided sufficient details, e.g. suitable temperature ranges were often not defined. Only a proportion of candidates recognised that repeating the experiments would improve confidence in the results and the necessary steps to process results, such as calculating means and rates, were frequently omitted.

BIOLOGY

Paper 9700/51
Planning, Analysis and Evaluation

Key messages

When planning an investigation, it is important to set out the work in a logical way and for it to be detailed enough for another person to follow.
When planning investigations, it is not necessary to copy out all the information given in the question paper. The information provided should serve as the basis for developing the particular method asked for in the question.
Conclusions need to be more than just a descriptive re-statement of the results provided. When looking for trends in data, the whole range of data should be considered rather than just raw data quotes alone.

General comments

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

Comments on specific questions

Question 1

(a) (i) Most candidates calculated the answer correctly.

(ii) Theoretically, the reaction time in this scenario should stay the same but it is reasonable to hypothesise that the time would increase so either was creditworthy. The question asked for reaction time and some candidates confused time with rate. A few candidates wrote in terms of slower reaction rate and gained some credit.

(b) (i) Some candidates found this question difficult. In this case, the dependent variable was the distance that the ruler dropped. The reaction time was then calculated from that data.

(ii) There were many clear and detailed plans which gained credit. Weaker responses simply copied out the basic procedure. Good answers started by making it clear how they would achieve the two desired conditions of quiet and noise by using some form of sound insulation or ear defenders. Weaker responses were less specific with the use of 'isolated' rooms. A variety of ways of achieving noise were given but those who gained maximum credit candidates stated that the volume or level of noise should be constant across the investigation. Some candidates did not appreciate that reaction time will vary between subjects and therefore more than 1 or 2 subjects would need to take part. Stronger responses focussed on the significant factors that needed to be controlled in the investigation, such as using subjects of the same age, always using the same hand to catch the ruler and carrying out the task at a standardised time of day. The idea of not giving the subject any warning as to when the ruler would be dropped was not often mentioned. Weaker responses listed everything that might be controlled regardless of whether it was relevant to the investigation, such as wind speed, light intensity or using the same bench. Many candidates stated that it is also important for subjects not to take drugs, caffeine or alcohol prior to the test. Some also recognised that subjects should be selected without specific medical conditions that might affect reaction time in the stated conditions, such as poor hearing or sight, or those on medication or stimulants. Many responses included replicating the test a suitable number of times but this was sometimes linked to calculating an average It is better to use the term 'mean' in scientific work. This was a low risk investigation. A few candidates gained credit by mentioning that noise levels should not be set at potentially damaging levels.

(c) Many candidates incorrectly stated that a bar chart was used because the data was discontinuous. The data was continuous and it was the independent variable that was discontinuous or categoric. Bar charts are used in situations where the independent variable is categoric. Weaker responses such as bar charts show the data more clearly, were too vague and not credited.

(d) (i) Most candidates correctly spotted that the reaction time was shorter in the presence of noise. As in **Question 1(a)(ii)**, a few answered in terms of the speed of reaction and were credited.

(ii) A majority of responses gained credit by indicating that the *t*-test was used to compare the means or by reference to continuous data. Some answers were too generalised for credit, such as 'seeing if the results were significant' or to compare the data without reference to the mean.

(iii) The majority of answers showed a good understanding of the null hypothesis. A common error was not to specify what 'no significant difference' was between. A few answers gave a description of the results rather than a null hypothesis and the weakest responses stated an alternative hypothesis based on a relationship or significant difference.

(iv) The majority of candidates gave the correct answer, demonstrating an understanding of how to interpret a probability table for a *t*-test. Weaker responses showed a poor understanding of what the *t* value represented. A significant minority misidentified the relationship as significant.

(e) (i) Many candidates gained credit for expressing the idea that the independent variable was the number of attempts at the task of drawing the star. A minority suggested the dependent variable i.e. 'the number of errors' or 'the different candidates' or even just 'the star'.

(ii) A number of candidates found this question difficult. Although it was not about reaction time, a significant number of responses answered in terms of an increase in the number of repeats decreasing the reaction time rather than an increase in accuracy. In some cases credit was still given as the candidate then went on to describe a reduction in the number of times the student drew outside the lines. Some responses did not give a direction to their hypothesis, stating that there was a relationship or correlation between repetition and accuracy without indicating what that relationship was.

(iii) Most candidates answered correctly, although a few left this blank. Some lost credit as they ringed more than one figure or ringed a whole row of results.

(iv) Most candidates gained credit for this answer, although a few were less sure of the reason and suggested it was student **Y** because they had been disturbed.

(f) The commonest creditworthy response was to state that repetition of the task increases accuracy. Candidates found it more difficult to give a second, clear, overall conclusion and tended to describe the increased accuracy in individual students or state that it varied. Good responses gained credit by stating that the increase in accuracy tails off after a certain number of repeats. Mention of the effect of interruption on accuracy was also creditworthy.

Question 2

(a) (i) Candidates were generally able to complete the calculation correctly. However, a significant minority of responses gave values for the volume of semen that were sometimes impossibly large, measured in millions of litres, or improbably small being only 1 mm^3 or so.

(ii) The mathematical process was nearly always carried out correctly. Credit was sometimes lost due to incorrect rounding. The values needed to be rounded up to 7 to give the minimum number of straws needed. Some responses were either rounded down or left unrounded which did not answer the question.

(b) There were good responses here which showed a thorough understanding of the use of haemocytometry with reference to systematic counting of cells, and the way in which the raw count could be converted to a value per cm^3. There was a lot of information on the diagram as to which sperm cells the technician had counted or ignored and candidates needed to examine the figure carefully to see how the systematic counting had been done. The answer also required clear expression to show that these ideas were understood. Some candidates did not mention that all the sperm fully inside the 0.25 mm · 0.25 mm square had been counted. Candidates also needed to be clear on the conversion of the count to a value in cm^3. The first stage was working out the volume of the haemocytometer and a large number gained credit for either doing this correctly or indicating that it needed to be done. Fewer were able to show how a value per mm^3 could be converted to cm^3. There were excellent answers which showed clear understanding and gained full credit. Less successful attempts were often out by a factor of 10 or 100 in their conversion.

(c) There were some excellent answers here gaining full credit for explaining the reasons behind the addition of the three substances to the semen. Less successful responses were either too vague to gain full credit or contained fundamentally incorrect biological statements.

The addition of sugar provided an energy source for energy release or ATP production in respiration, and this was covered in various ways in creditworthy responses. Some candidates demonstrated the fundamental misconception that energy is made, or just stated the sugar is for' energy or for nutrition, which is not sufficient. Credit was given for the idea that the sugar would maintain the water potential of the sample.

A significant number of candidates simply repeated from the question that the buffer was added to maintain the pH rather than explaining that it was to prevent the denaturing of the enzymes/proteins in the sperm. Creditworthy responses covered this well. There were cases of biochemical misconceptions such as ‘killing the enzymes’ or ‘denaturing the sperm’ and general ideas like ‘protecting the sperm from acids’, none of which were able to gain credit.

The addition of antibiotics would kill, or at least reduce the growth and reproduction of bacteria, which was the most common creditworthy response. The effect of this, to prevent infection or damage from bacteria, was also credited. There was some misconception that antibiotics would kill viruses and some responses referred to antibiotic resistance and immunity, which were not creditworthy. General, unqualified references to ‘fighting bacteria’ or ‘protecting against bacteria’ were not sufficiently detailed to be awarded credit.

BIOLOGY

Paper 9700/52
Planning, Analysis and Evaluation

Key messages

- Candidates are advised to read through the whole question prior to answering.
- When planning an investigation, it is important to set out the work in a logical way and for it to be detailed enough for another person to follow.
- When planning investigations, it is not necessary to copy out all the information given in the question paper. The information provided should serve as the basis for developing the particular method asked for in the question.
- Conclusions need to be more than just a descriptive re-statement of the results provided. When looking for trends in data, the whole range of data should be considered rather than just raw data quotes alone.

General comments

The responses covered the full range of credit available and there was no evidence that the candidates were short of time on this paper. There was evidence that many candidates had an understanding of statistical ideas.

Comments on specific questions

Question 1

(a) (i) Many candidates were able to identify at least one reason why Method 2 was the most suitable, with the most common answer being that it was easy to explain to subjects or easy for subjects to carry out. Credit was given for answers stating that some subjects might not be able to catch a ruler or cannot move easily; this is not the same as subjects do not have to catch a ruler or do not have to move easily. Candidates need to be clear of the distinction between the terms accurate, reliable and error. These terms were used interchangeably by some candidates and as such, some did not receive credit. Fewer candidates were able to provide two separate reasons, with many repeating their first answer.

(ii) Almost all candidates identified the dependent variable as reaction time. Candidates need to be clear that the independent variable is something that is manipulated by the person conducting the experiment, in this case the age of the subjects. A few candidates had the same answer for both the independent and dependent variables and therefore, could not gain credit for either.

(iii) There were many clear and detailed plans which gained credit. Less creditworthy responses tended to just copy out the basic procedure, which was not required. Candidates were required to use the basic information to develop a clear and logical scientific investigation to address the specific question regarding the effect of age on reaction time.

Good answers started by making it clear how they would choose subjects of different ages by placing them into age categories or by testing one person of each age from 5 to 80. Less creditworthy were rather more nonspecific responses which repeated the information provided in the question to test a sample of people aged from 5–80. Some candidates suggested placing subjects into age categories, such as ages 20–30 and 30–40. This resulted in a person aged 30 being in two age categories and therefore, did not receive credit.

When considering things that should be standardised, candidates should appreciate which are the significant factors to control in any given investigation rather than give a long list of anything that might be controlled, regardless of whether it is really relevant to the investigation in question. Creditworthy responses were common and included ideas about standardising the type of computer or colour change and not using subjects who had taken drugs / caffeine / alcohol prior to the test. Those candidates who did not gain credit were not specific enough in their response, referring to subjects not drinking, rather than what specifically the drink may contain. The important idea about gaining consent when using human subjects was not often mentioned; when it was, excellent suggestions about subjects signing consent forms were seen. Many candidates appreciated the importance of selecting subjects without specific medical conditions that might affect reaction time in the stated conditions, such as poor sight, or neurological disorders.

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

This was a low risk investigation. A few candidates gained credit by mentioning that bright light from the computer screen may damage eyes and suggested a suitable precaution against this.

(b) (i) Most candidates gave a correct answer. Careful reading of the instructions was essential as although some used the correct values and processed them using the correct calculation, they did not then give the answer to the nearest whole number, meaning that full credit could not be awarded.

(ii) To gain full credit, it was necessary for candidates to study the graph carefully and consider the whole range of data in order to make conclusions about the trends shown. Successful responses referred to reaction time being higher in females than in males for most ages. Many candidates discussed the reaction time decreasing up to age 20 years or increasing after this age. To improve answers, candidates should include what happens before and after a change in direction to receive credit. Relatively few candidates made reference to the standard deviation bars and if they overlapped or not. Candidates need to make use of all the information provided in a question in order to gain full credit. A few candidates commented on faster or slower time, which did not gain credit.

(iii) Many candidates gave a correct answer, stating that a *t*-test should be used. Correct reasons gaining credit were that the data is continuous or to compare two means. A few candidates also correctly stated that the standard deviations were approximately the same. Credit was also given if reference was made to the data being normally distributed.

(iv) The majority of answers showed a good understanding of the null hypothesis. A few answers gave a description of the results rather than a null hypothesis. Common errors were to state there is a relationship or a significant difference – in other words to state the alternative hypothesis. Another common error was not specifying what 'no significant difference' was between.

Question 2

(a) (i) There were some good responses here which showed a thorough understanding of the use of haemocytometry with reference to systematic counting of cells. The very best answers included detail such as only including sperm cells which were touching the top and left line and excluding those touching the bottom and right line. Less successful attempts made reference to the area of each square rather than the volume. A few did not appreciate that they were dealing with sperm cells which needed to be viewed under a microscope and made reference to capture, mark and recapture techniques.

(ii) Many candidates were able to multiply the number of sperm by the dilution factor provided in the stem of the question in order to estimate the number in the undiluted semen sample. Fewer candidates were able to describe how they would estimate the number of sperm per mm^3. Candidates needed to use the dimensions provided in the question to calculate the volume of 1 square on the grid and then divide the number of sperm in that square by the volume.

(iii) Many candidates were able to identify a reason why counting sperm using a grid may not represent the actual number of sperm in the undiluted sample. The most frequently seen successful answer was that the sperm cells may not be evenly distributed in the grid. Other common answers included that the sperm were moving; in order to gain credit for this point, reference also needed to be made that since the sperm were moving, this made it easy to miscount them. Fewer candidates made the link that the semen on the grid was only a sample of that produced.

(b) (i) Most candidates had read the information provided and were able to gain some credit for this question. A few candidates described what should have been standardised rather than what had been standardised. A few gave generic answers of standard variables that might apply to many different experiments. Some referred to only males being tested. Candidates need to ensure that they apply their answers to the specific question being asked.

(ii) The majority of candidates gave a correct answer, commonly for a control or for comparison.

(iii) Candidates needed to include detail about the type of infertility the men were suffering from and the levels of both FSH and LH to gain credit. Candidates could improve on their responses when asked to write a conclusion by using all the information provided, especially if a key is included in a chart. The most successful responses addressed the specific question asked and were supported with careful analysis of the data.

(c) There were two parts to this question. Firstly, to provide a method for counting the number of live and dead sperm cells. Secondly, to use the information provided in the question about what viability meant and suggest how this could be found. Successful responses identified that the live and dead sperm would be stained different colours and therefore, could be counted separately. Expanding on this to suggest a method to calculate the proportion of live to dead sperm, and so gain full credit, was seen in fewer responses. The most common method provided was to divide the number of live sperm by the total number of sperm. Candidates should use the terminology provided in the question when faced with information from an unfamiliar context.

BIOLOGY

Paper 9700/53
Planning, Analysis and Evaluation

Key messages

- When planning an investigation, it is important to set out the work in a logical way and for it to be detailed enough for another person to follow.
- When planning investigations, it is not necessary to copy the information given in the question paper. The information provided should serve as the basis for developing the particular method asked for in the question.
- When candidates are asked whether data or results supported a conclusion or not, such as in **Question 1(d)(iv)**, raw data quotes alone are not sufficient; they must be qualified.

General comments

The responses of candidates to this paper covered a wide range of marks with a number of excellent papers seen. There was no indication that candidates were short of time.

Comments on specific questions

Question 1

(a) (i) Most candidates were able to identify the independent and dependent variables correctly.

(ii) Many responses correctly identified the type of independent variable as categoric or an equivalent term. The majority of incorrect responses stated a specific variable, such as a person's sex or their speed of reaction, rather than the type of variable.

(iii) There were many good methods described. Some responses gained no credit due to only copying out the information given at the start of the question. Better responses included good detail regarding the standardisation of the equipment and conditions. A few responses were too general, such as 'use an isolated room' without making clear what this controlled. Not using subjects who had taken drugs, caffeine or alcohol prior to the test was often mentioned and credited. Many responses mentioned replicating the test a suitable number of times but this was sometimes linked to calculating an average. The term 'mean' should be used in scientific work. It was not always mentioned that the investigation was low risk. Some responses correctly identified epilepsy as a possible risk but often did not follow this up by stating that such subjects should be excluded from the test. A few candidates chose a different reaction time test to see if girls and boys differed in their response time.

(iv) Many candidates gained credit from good descriptions of processing delay or lag and poor or variable internet connections or speed. This was not a question about operator errors such as getting tired.

(b) Most candidates successfully calculated the required values.

(c) (i) The majority of responses gave an appropriate reason for why the *t*-test was suitable for analysing the data. The responses correctly covered the ideas of comparing the means of two sets of continuous, normally distributed data. Some weaker responses simply suggested that the *t*-test was to see if the difference was significant, effectively copying out the question, and therefore received no credit.

(ii) Most candidates showed a good understanding of the null hypothesis. A few stated an alternative hypothesis rather than the null hypothesis. The commonest error was to not mention that this investigation was carried out on right-handed people. A few modified the investigation further to state that there is no difference in reaction time between right-handed and left-handed people. Careful reading of what was actually done was required to avoid such errors.

(iii) The data given was in pairs from the same individual and so a paired *t*-test would have been carried out and the number of degrees of freedom was 20. Although this was recognised by many candidates, some stated that it was 10, so assumed that an unpaired *t*-test would have been carried out.

(iv) This was generally well understood with responses stating that the students' calculated *t* value would have been less than 2.09 (or less than 2.23 if they had calculated the degrees of freedom as 10 in **Question 1(c)(iii)**). A few incorrectly stated that the calculated value would be greater.

(d) (i) The anomalous result was spotted by the majority of candidates. A few candidates incorrectly ringed the mean value for student 3.

(ii) The majority of responses correctly suggested that the result should not be included in the calculation of the mean. Some elaborated on this by saying it should still be recorded to indicate there was an anomaly. A few candidates suggested that all three responses for the eleventh attempt should be removed. As each student carried out the task in a separate room, this would not be necessary.

(iii) The majority of candidates identified that student 3 drew lines that were most inconsistent in length because ***s*** (standard deviation) was the greatest. Some responses were too generalised, simply stating that student 3 made more mistakes.

(iv) Many responses described good supporting evidence for the conclusion, realising that after feedback the means became closer to the actual measurement. Responses were weaker for not supporting the conclusion. The most common response gaining credit was the idea that in student 3, the improvement in closeness to 7.5 cm was minimal – from 1.5 cm over to 1.4 cm under the actual length attempted. Many quoted figures, but these needed to be given in the context of the ideas regarding closeness to the actual length. Credit was also available for the concepts that for a conclusion to be supported there should be more than three candidates tested and the data should be tested statistically to gain evidence that any differences were significant.

Question 2

(a) (i) This was well answered with many achieving maximum credit. The commonest errors were to use the term 'amount' in place of 'volume'. A few candidates mentioned the mass of DNA or sperm or the X and Y chromosomes being standardised, none of which were credited.

(ii) Responses that gained credit either by suggested that too high a spinning speed might damage the whole sperm or might result in no separation of X and Y sperm as both would be spun to the bottom of the tube. Some responses talked more generally about harming the semen or too specifically about splitting up the DNA, rather than focussing on the whole sperm. A few candidates incorrectly suggested that too high a speed might cause the sample to be ejected from the tube.

(b) Most candidates answered correctly.

(c) The best responses showed a thorough understanding of the use of haemocytometry with reference to systematic counting of cells and the way in which the raw count could be converted to a value per cm^3. Other candidates had difficulty explaining the concept of using a grid to count in a systematic way. There were a small number of responses which did not mention that all of the sperm cells fully inside the 0.25 mm × 0.25 mm square would be counted. The systematic element of the counting required a description of which sperm cells at the edge of the field of view were included and various methods were credited. Some candidates considered the quality of the sample which was credited if it was linked to a visible aspect of sperm cells, such as not counting those with two heads or deformed heads.